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Establishing Traces for the Working of Nautilus Shell in Prehistory

Gavin Parkinson

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Abstract

In 1994 and 1996, Peter Bellwood and colleagues excavated Golo Cave, an archaeological site on Gebe Island, eastern Indonesia. This excavation uncovered a number of artefacts, including examples of modified shells. Fragments of *Nautilus pompilius* were also uncovered, however, due to difficulty identifying traces of working on the unique structure of *Nautilus* shell, it was uncertain if these fragments represented worked samples or not. This paper presents the findings of a number of experiments aimed at determining the origins of the *Nautilus* shell fragments recovered from Golo Cave.

Firstly, whole shell specimens of *Nautilus* shell were fractured using an INSTRON machine to generate examples of an edge formed through natural compaction. Secondly, a number of materials were used to experimentally work modern samples of *Nautilus belauensis*, with particular attention paid to abrasion and score-snap experiments. The INSTRON and experimentally worked samples were then examined using both low-power and scanning electron microscopy (SEM) to identify the traces of natural breakage and deliberate modification respectively. Once these traces had been established, the *Nautilus* samples from Golo Cave were also examined using low-power and high-power (SEM) microscopy to identify any similar patterns between the INSTRON fractured samples or the experimentally worked samples. It was found that some of the Golo Cave fragments had indeed been deliberately worked by humans, with positive identification of working traces found on some of the samples. Naturally fractured edges were also recognised on Golo Cave fragments when compared to the INSTRON fractured specimens. An ethnographic study within this project also examined the past and current use of *Nautilus* shell as a raw material in a Solomon Island context to gain a better understanding of the practical and cultural significance of its use in the present day and the past. This component was used to develop the methodology for this project, but also found that the general trend of *Nautilus* shell use has transitioned from having a strong cultural and spiritual importance to having a more economic importance in recent decades.

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Establishing Traces for the Working of *Nautilus* Shell in Prehistory

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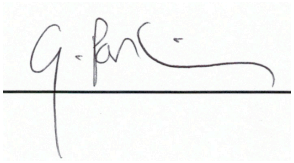

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Firstly, whole shell specimens of *Nautilus* shell were fractured using an INSTRON machine to generate examples of an edge formed through natural compaction. Secondly, a number of materials were used to experimentally work modern samples of *Nautilus belauensis*, with particular attention paid to abrasion and score-snap experiments. The INSTRON and experimentally worked samples were then examined using both low-power and scanning electron microscopy (SEM) to identify the traces of natural breakage and deliberate modification respectively. Once these traces had been established, the *Nautilus* samples from Golo Cave were also examined using low-power and high-power (SEM) microscopy to identify any similar patterns between the INSTRON fractured samples or the experimentally worked samples. It was found that some of the Golo Cave fragments had indeed been deliberately worked by humans, with positive identification of working traces found on some of the samples. Naturally fractured edges were also recognised on Golo Cave fragments when compared to the INSTRON fractured specimens. An ethnographic study within this project also examined the past and current use of *Nautilus* shell as a raw material in a Solomon Island context to gain a better understanding of the practical and cultural significance of its use in the present day and the past. This component was used to develop the methodology for this project, but also found that the general trend of *Nautilus* shell use has transitioned from having a strong cultural and spiritual importance to having a more economic importance in recent decades.

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Chapter 1 – Introduction

Nautilus shell has a unique micro- and macro-structure that is designed to withstand high pressure within the pelagic zone of the ocean that it inhabits (Chamberlain & Chamberlain 1985). This structure causes *Nautilus* shell to respond differently to modification and exhibit a unique fracture pattern when compared to other shell species (Currey 1977). *Nautilus* shell fragments have been recovered from Golo Cave on Gebe Island, Maluku Province, eastern Indonesia, with the earliest samples dated to between 32,000 and 28,000 Ka (uncalibrated) before present (Bellwood et al. 1998). Due to the deep-sea habitat of the *Nautilus*, these shells were most likely collected as dead specimens and not as a food source, as is more commonly the case with most other species of shell recovered from archaeological sites (Szabó 2013, p. 280). They also appear to have been cut into shape, however, little research has been conducted into how *Nautilus* shell behaves as a raw material from an archaeological perspective, making the identification of worked fragments difficult to achieve.

This project aims to establish whether the Golo Cave *Nautilus* fragments are indeed worked shell. This will be achieved through INSTRON breakage experiments on whole *Nautilus* shells, followed by a series of working experiments using different materials (including flaked stone, branch coral, ray skin and sea urchin spine) on *Nautilus* shell fragments. The breakage patterns of the resultant samples will then be analysed using low- and high-power microscopy. With the accumulated evidence from these experiments, the *Nautilus* fragments from Golo Cave can be determined as either having been deliberately modified or not.

This project has four distinct aims:

1) To investigate and record natural breakage patterns in *Nautilus* and how these relate to shell macro- and microstructure

2) To investigate traces left on the microstructure of *Nautilus* shell by experimental working techniques
3) To study and record the historical and present cultural use of *Nautilus* as a raw material in a Solomon Island context
4) To analyse and interpret the archaeological samples from Golo Cave based on the fulfilment of aims 1-3

Based on current literature by Bellwood et al. (1998), Szabó (2013, p. 280) and Szabó and Koppel (2015), the hypothesis for this project is that fragments of *Nautilus pompilius* recovered from Golo Cave have undergone modification by human inhabitants of Gebe Island in prehistory. Several other species of shell have already been identified as worked samples (Szabó & Koppel 2015), with preliminary observations of the *Nautilus* shell fragments showing possible signs of deliberate working (Szabó 2013, p. 280).

This research will be important not only for the better understanding of shell working in Golo Cave, but also for *Nautilus* shell in general. Little is known about *Nautilus* shell as a raw material, particularly in an archaeological context – a point that this project aims to remedy. This project will also allow for the development of this experimental methodology, as piloted by Szabó and Koppel (2015) and Weston et al. (2015). The methodological technique utilised in this study is easily adapted to a wide range of contexts and may prove useful for the establishment of working traces on a wide range of materials in future.

Chapter 2 - Background

The key contextual background for this project lies in the importance of the site at which the archaeological fragments of *Nautilus* were recovered, as well as the key structural features of the *Nautilus* shell itself. Golo Cave presents us with some of the oldest shell working by *Homo sapiens* in island southeast Asia (Szabó et al. 2007; Szabó 2013, p. 280), and as such, can provide an insight into the progression of this technology throughout the region.

The presence of *Nautilus* in the Golo Cave assemblage is highly significant. Other examples of worked shell in Golo Cave are believed to have been collected as a food source and recycled later, however, due to its deep-sea habitat *Nautilus* could have only been collected dead if it was used as a raw material (Szabó 2013, p. 280). This has strong implications for the possible cultural significance of the *Nautilus* in the prehistory of the region.

Golo Cave

Several studies have already been conducted on shell artefacts recovered from Golo Cave (e.g. Szabó et al. 2007; Szabó 2013; Szabó & Koppel 2015). These studies give helpful insight into several aspects of the archaeological site, while others (such as the *Nautilus* fragments at the site) are yet to be interpreted.

Golo Cave (Figure. 2.1) (formed in uplifted coral) is located on the eastern Indonesian island of Gebe in the Maluku Islands. Peter Bellwood and colleagues first excavated the cave in 1994 and again in 1996 (Bellwood, 1998). From these excavations, shell from one square was retained as a complete sample, and could be further analysed for the presence of shell working.

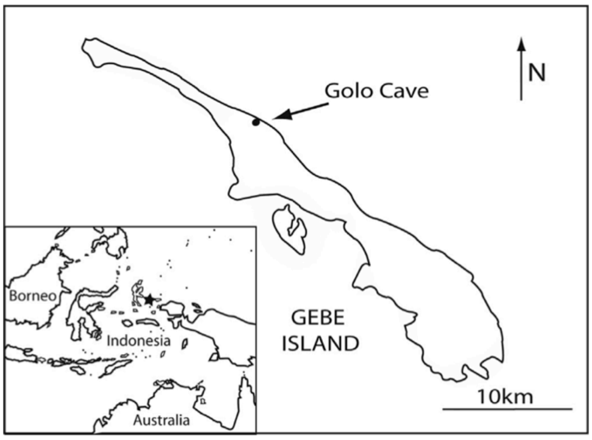

Figure. 2.1: Location of Golo Cave, Gebe Island. Szabó and Koppel, 2015.

Several examples of worked shell have been identified and described from this site; including *Scutellastra flexuosa* (limpets) being used as unmodified scrapers (Szabó & Koppel 2015), as well as flaked and reduced *Turbo marmoratus* shells (Szabó et al. 2007). Dating has indicated an uncalibrated age of between 28,000 and 32,000 Ka for early worked shell examples. Such a date makes the working of these shells some of the oldest examples of this practice in an island southeast Asian context (Szabó 2013, pp. 277-286). Szabó et al. (2007) state that the presence of shell and bone artefacts on Gebe Island at least partially represents supplementation of raw materials, as the island is somewhat deficient in quality lithic resources.

The archaeological samples collected from Golo Cave may provide an important insight into the use of *Nautilus* as a raw material, however, for them to be understood in a working context, the structural and physical properties of the shell must first be analysed. The fracture tendency of the *Nautilus* shell is one of the critical factors affecting its use as a raw material. These fracture patterns are effectively determined by the micro- and macro-structure of the shell, meaning that these factors will be paramount in understanding the *Nautilus* structure and physical properties.

Habitat

Geographic

There are fewer than six remaining species within genus *Nautilus*, all of which are found in the southwest Pacific (Abbott & Dance 1983, p. 377). The *Nautilus* is native to the Indo-Pacific region, with De Angelis (2012) listing 17 countries where the *Nautilus* is found. Included in this list are the two main focus areas for this project, the Solomon Islands and Indonesia.

Depth

Dunstan et al. (2011) state the habitable range of the *Nautilus* to be between 130 and 700 metres, with little to no variance between juvenile and adult specimens. These data were acquired using ultrasonic telemetry as well as 29 hours of live observations via remotely operated vehicles in the depth range of 100 to 800 metres. This habitable range is considerably deeper than most marine molluscs due to the unique structure and microstructure of the *Nautilus* shell which buffers against the effects of water pressure (Clarkson 1998). *Nautilus* do not inhabit inshore environments.

Microstructure

Composition

As stated by Arnold et al. (1990), *Nautilus* shell is composed of calcium carbonate and organic compounds known as glycoproteins (a polypeptide chain with carbohydrate groups attached), with *Nautilus* appearing to contain a higher content of organic compounds compared to other shells (Clark 1999). The *Nautilus* shell is composed of a phase of calcium carbonate called aragonite, which appears to be the only present mineral in the *Nautilus* outer shell and septa (Brand 1983). The microstructure of the *Nautilus* nacreous layer shows aragonitic prisms stacked in columns and sheets, described as ‘inside columnar nacre’ (Chateigner et al. 2000). The *Nautilus* shell is coated by a periostracum – an organic coating over the outside of the shell (Ward 1988) as found on most molluscs and brachiopods. Ward (1988) suggests that this periostracum may adhere to the lines on the outermost layer of the *Nautilus* shell.

Features

The *Nautilus* microstructure is divided into three distinct sections: An outer spherulitic prismatic layer (being porous in nature), a middle prismatic layer (also thin and porous) and an inner layer consisting of nacreous and organic components (Mutvei & Donovan 2006).

The outer surface of the spherulitic prismatic layer of the shell appears to have ridges that run parallel to the aperture of the shell (Ward 1988). These ridges may serve the function of helping with the adhesion of the periostracum layer on the outside of the shell. They may also be a means to direct breakage of the shell in a direction that would cause the least damage and be the easiest to repair. As noted by Currey and Kohn (1976) when studying *Conus* shell, breakage to the shell whorl and damage running perpendicular to the aperture would cause the greatest damage to the living organism. Ridges of this nature are a mechanism by which to better prevent this damage. The microscopic structure of this spherulitic prismatic layer is arranged so that extended prisms radiate outwards from a single point to form a series of spherulitic structures (Watabe 1988).

Scanning electron microscopy (SEM) conducted on the nacreous layer by Clark (1999) shows a continuous organic layer of around 0.1 μm thickness that envelops the nacreous lamellae. This organic layer is comprised of conjoined nodules with interstitial pores throughout. This unit of the microstructure is believed to be the reason for the more abundant preservation of the inherently unstable aragonite tablets within the shell, as the organic layer protects the unstable aragonite from chemical degradation after the specimen has died. The connections between these organic matrixes were observed by Clark (1999) to be considerably thinner, and hence, weaker than the sheath-like structure of the organic layer. These connections ranged from 0.02 to 0.05 μm in thickness and consisted of lacey and multiple sheet textures. Checa et al. (2011) describe the *Nautilus* nacreous structure using a brick and mortar model; with 5-15 μm wide 'bricks' of aragonite surrounded by organic material acting as a 'mortar' layer. These 'bricks' are each offset in relation to the others around it so that there is no direct line of weakness throughout the layer (Currey 1980).

While a significant amount of research has been done on the microstructure of *Nautilus*, very little has been conducted into the traces left on this structure through breakage and working of the shell.

<u>Macrostructure</u>

Features

The *Nautilus* shell consists of a phragmocone divided into separate chambers by plates called septa (Figure 2.2). These septa are grown episodically with the organism moving forward to occupy the most anterior chamber of the shell as a new septum is formed behind it (Vermeij 1993). Each septum is then transversed by a tube, called a siphuncle, which is able to remove fluid from or flood the previous chambers through osmosis (Clarkson 1998, pp. 231-234). This siphuncle is comprised of a nacreous component and a permeable membranous component (Collins 1967). At the time of hatching, the *Nautilus* already has around seven chambers formed. This number may increase to greater than thirty with maturity.

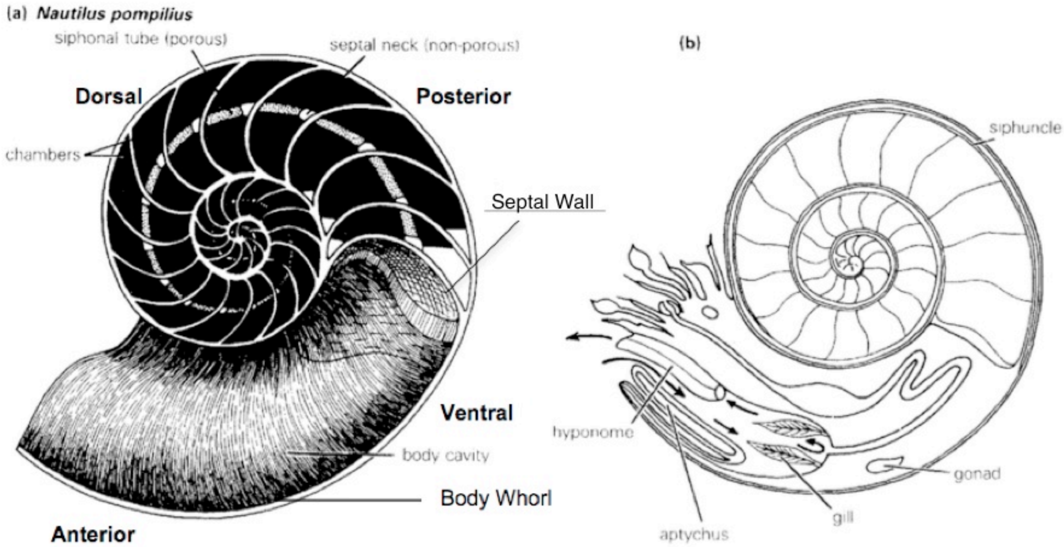

Figure 2.2: Structure of the *Nautilus* shell. Adapted from Clarkson, 1998.

The experimental component of this study will be conducted on specimens of *Nautilus belauensis* (endemic to Palau). As this is a different species to the more common *Nautilus pompilius* (as found in Golo Cave), any differences must be assessed to determine their effect on the results obtained.

Difference between *N. belauensis* and other *Nautilus* species

Geography/habitat

Saunders (1981) was the first to describe *Nautilus belauensis* after its discovery in 1976. As noted by Saunders, *Nautilus belauensis* is endemic to the waters around Palau in the western Pacific where it lives in the fore-reef zone at depths ranging from 125-200 metres.

Microstructure

The composition of the *Nautilus belauensis* shell is calcium carbonate plus organic compounds (Arnold et al. 1990). This composition is the same as *N. pompilius*. There is no significant difference in the concentrations of elements in *Nautilus* shells across different species and, as noted by Pernice et al. (2009), any minor variation in elemental concentration within *Nautilus* shell is most likely the result of environmental factors such as volcanic enrichment of the waters in which *Nautilus* live. The general microstructure of the *Nautilus* does not vary significantly between *N. pompilius* (as found in Golo Cave) and *N. belauensis* (as used for the experimental portion of this study) and have been described as sibling species (Saunders & Landman 2009, p. xli). Both species exhibit the three distinct sections of an outer spherulitic prismatic layer, a middle prismatic layer and an inner nacreous layer (as seen in Figure 2.3).

Figure. 2.3: *Nautilus belauensis* microstructure showing the nacreous tablets (bottom) and prismatic stacks (top). Scale bar (bottom right) = 1 μm, Arnold et al. 1990.

The only notable difference in the layered structure of the *N. belauensis* is that the organic coating on the shell, or periostracum, appears to be significantly thicker than is found on *N. pompilius* (Ward 1988). The periostracum on a juvenile *N. belauensis* can be up to 1 mm thick, whereas the same layer on *N. pompilius* is generally only around 1-5 μm thick. This layer is usually only found on juvenile specimens and is believed to abrade away by the time the specimen reaches maturity. This means both the samples from Golo Cave and the samples intended for use in the experimental phase of this study would both be highly unlikely to contain a periostracal layer and examination of specimens confirms this.

Macrostructure

Nautilus belauensis is one of the largest species of *Nautilus* with an average shell diameter of 204 mm and a weight of 1308 grams (Saunders 1981). *Nautilus pompilius* is generally smaller with an average shell diameter of around 128 mm (Dunstan et al. 2011). *N. belauensis* may be thicker than *N.*

pompilius proportional to its size. This size variation is the main macroscopic difference between *Nautilus belauensis* and *Nautilus pompilius*. To be understood as a raw material, the fracturing of the *Nautilus* shell must be examined. It is also important to understand the process of shell transport after death, as this is a key component in how *Nautilus* shell came to be collected and used when its habitat is generally too distant to be harvested by the inhabitants of locations such as Golo Cave.

<u>Fracturing and transport</u>

Fracturing

The nacreous composition of *Nautilus* shell makes it significantly stronger than most other forms of shell (Currey & Taylor 1974). In a study on the strength of molluscan hard tissue by Currey and Taylor (1974), *Nautilus* shell was found to withstand forces up to 207 NMm^{-2} before fracturing. This value was only surpassed by *Turbo* shell at 276 NMm^{-2}. As a material, nacre exhibits a considerably higher tensile and compressional strength than the shell as a whole (Saunders & Wehman 1977), with whole shells generally experiencing structural failure at points of weakness – such as flaws in the shell or at areas of microstructural variation. It has also been noted by Currey (1988) that the cracking of nacreous material occurs in the organic layer between the aragonite tablets as opposed to through the aragonite tablets themselves. This has significant implications for the expected microstructure of the broken and unworked edges to be produced in the experimental component of this study.

Wani (2004) performed several experiments on *Nautilus* shells to replicate taphonomic processes likely to cause shell breakage. These included transport with sediment, sediment loading and collision during floating. The most relevant process to the study area of Golo Cave would likely be sediment loading – with *Nautilus* fracturing under the weight of overlying sediments (with grain size having little to no impact on the weight of the load before fragmentation of the shell). The experimental results showed that in the sediment loading experiments, the main type of break incurred by the *Nautilus* shell was on the body whorl of the shell, adoral to the final septum. This would appear to support the idea of the ridges on the outside of the spherulitic prismatic layer functioning to direct any breakage along the shell aperture. A study by Yomogida and Wani (2013), which assessed the repair patterns in *Nautilus* shell, also found that breakage most often occurred in the region between the final septum and the adoral end of the shell. These studies did not investigate the nature and morphology of fractured edges at the micro-scale.

Transport

A study by Wani et al. (2005) provides an insight into the transport of the *Nautilus* shell after death. Deposition of the shell generally occurs once the shell has become waterlogged and sinks. Wani et al. (2005) used *Nautilus pompilius* specimens to study the timing of waterlogging after death of the *Nautilus* and were able to establish that this phenomenon does not occur immediately after death. In order for the shell to become waterlogged, the soft body of the *Nautilus* must first separate from the shell at the mantle attachment. This separation does not guarantee the sinking of the shell – as demonstrated by the removal of the soft *Nautilus* tissue and observing the empty shells remaining afloat in floating cages in the ocean. This experiment saw some *Nautilus* shells remain buoyant for over 264 days. This floating time may represent huge distances travelled via external environmental factors (such as winds and ocean currents), easily resulting in *Nautilus* specimens washing ashore in places such as Gebe Island. In a tag and release study by Saunders and Spinosa (1979), a deceased *Nautilus* shell was found to have drifted for a period of 138 days, covering a distance of 1000km.

While the physical and geographical aspects of this study are essential for the understanding of *Nautilus* shell working, there are also significant ethnographic and archaeological aspects to this study. The cultural significance of *Nautilus* shell and its use as a raw material cannot be overlooked. For this reason, several considerations must be made regarding the use of *Nautilus* shell throughout history – not only in a western-Pacific context, but also throughout the world.

Ethnoarchaeology

Ethnography

The main focus of the ethnographic component of this project will be centred on the Solomon Islands. This is due to the fact that the Solomon Islands have a very strong tradition and history with the use of *Nautilus* as a raw material for the creation of many different kinds of artefact that continue today. One of the main historical uses of *Nautilus* is the inlaying of the *Nautilus* shell within prow ornaments of canoes in the Solomon Islands, particularly those from the Western Province (Thomas 1995, pp. 90-94). These canoes were primarily used on headhunting expeditions in which warriors from one island would invade other islands to engage in traditional warfare against other tribes. The canoes on which these voyages were taken are therefore of strong cultural importance. They were adorned with culturally and spiritually significant artefacts in order to allow a successful headhunting mission, and consequently, the working of *Nautilus* shell for the inlaying of canoes for these expeditions is of the highest quality (Thomas 1995, pp. 90-94).

The *Nautilus* shell itself has been linked to providing good luck and helping to ensure success in a number of important early Solomon Island traditions such as head hunting (Western Province) and fishing (Makira-Ulawa) (Hill 1996, p. 89). It is also suggested that whole specimens of *Nautilus* shell were sometimes placed on the roofs of houses to provide protection for the household (Hill 1996, p. 89). This once again suggests that the shell had deep cultural significance and was associated with the protective spirits depicted in the carving also adorned with *Nautilus* shell inlay (Hill 1996, p. 89).

The significance of the cultural use of *Nautilus* for this project is that the history of cultural use in the Solomon Islands can be traced into the distant past of the region. This may have implications for the use of *Nautilus* in eastern Indonesia, and in Golo Cave in particular. The fact that this shell has played a significant role in the cultural traditions of the Solomon Island people for so long may translate across the region, with the working of *Nautilus* shell in other areas possibly also exhibiting this strong cultural connection.

Nautilus not only serves as the basis for a significant proportion of the artefact creation and inlaying in Melanesia, but was also a prominent and highly sought after artistic material in China as early as the 15th century, and throughout Europe in the 17th century (Thomas 2007, pp. 36-37, 192). The iridescent nacreous layer of the *Nautilus* shell made it an attractive material to many master carvers in 17th century Europe, particularly in Holland. The shell was carefully prepared in order to strip the thin outer prismatic layers to reveal the nacreous layer beneath. Carvers were required to be particularly careful when carving *Nautilus*, as it was liable to fracture if carved incorrectly. In a modern context, *Nautilus* is still used as a raw material in the Solomon Islands. Although the working of *Nautilus* mainly originates in the Western Province, it may be found all over the Solomon Islands (Meyer 1995, pp. 398-405) but it also has a significant focus in modern Honiara (the nation's capital). This is due to the large foreign market established in this region as a result of the arrival of overseas tourists looking to acquire local craftworks (Burt & Bolton 2014, pp. 124-125). Thus, examples of *Nautilus* craftwork found in Honiara may originate from a wide variety of sources across the Solomon Islands.

Archaeology

Worked *Nautilus* shell has been recovered in a number of archaeological settings. Timor-Leste hosts a number of sites containing worked *Nautilus* shell, usually in the form of shell beads (Glover 1986). Glover (1986) describes worked *Nautilus* shell beads from three sites in Timor-Leste with ages ranging from 2300-5900 BP. Beads of a similar nature are also described by O'Connor (2010), with ages dating back to the early Holocene. These beads show a continuation of working over a period of several thousand years with very little change.

Another excavation in Liang Bua – a limestone cave in Flores, Indonesia, also found examples of worked *Nautilus* shell. The *Nautilus* fragments recovered from this site were at a depth of 40-50 cm, dating from the Holocene (van den Bergh et al. 2008). At least one of these Liang Bua fragments exhibited scoring on the nacreous surface, which indicates that the working of *Nautilus* shell in Golo Cave is plausible, as it has been found in a very similar geographic and region and timeframe.

Langley et al. (2016) describe an assemblage of five *Nautilus* shell artefacts uncovered from Jerimalai, Timor-Leste. These fragments are noted to have traces of working and ochre staining, with two of the five artefacts being dated by association to between 38,000 and 42,000 calibrated BP. The paper claims that these fragments have been worked using a number of techniques including abrasion and pressure flaking using a number of lithic and non-lithic resources. The methodology used in the Langley at al. (2016) paper to determine the origin of these fragments does not take common techniques of *Nautilus* shell working into consideration. Furthermore, the details given for the experimental working of modern *Nautilus* fragments for later comparison against archaeological samples leave out crucial technical details and seem to suggest a rather unstructured and unsystematic approach to the experimental design. The paper claims that the experimental process used by Langley et al. (2016) indicates the shell has been worked with the techniques and materials specified. This interpretation of the fragments following flawed experimental techniques casts doubt on the results obtained, as well as their overall significance. These flaws in technique will be examined more closely in Chapter 8 (Discussion); while a more suitable methodology for determining the origin of potentially worked shell fragments will be explained in the following chapter.

Chapter 3 – Methods

3.1 – INSTRON

In order to analyse and interpret the archaeological *Nautilus* fragments from Golo Cave, it was essential to also have separate samples of *Nautilus* shell with an experimentally worked edge and an unworked edge. This unworked edge served as a control and enabled the comparison between unworked *Nautilus*, experimentally worked *Nautilus* and the *Nautilus* fragments found in Golo Cave. This comparison essentially became the determining factor in interpreting the origins of the Golo Cave fragments. As such, controlled and systematic breakage of the *Nautilus* shell was essential for this research to be successful. This breakage produced fragments that can be considered analogous to an unworked *Nautilus* shell fragments broken through compaction.

If the samples of *Nautilus* recovered from Golo Cave were not worked in any way, but instead fractured as a result of taphonomic processes, it is probable that this fracturing would have occurred as a result of compressional forces due to compaction during deposition and burial of the shell. To create *Nautilus* fragments that are able to represent taphonomically broken samples, breakage must take place in a controlled setting and with repetition to consider different planes of breakage that may have been encountered during compaction. To achieve this, three whole-shell specimens of *Nautilus belauensis* were subjected to compressional forces in three separate planes. These three planes included dorsal/ventral compaction, lateral compaction and anterior/posterior compaction. These represented the three most likely planes of stress being exerted on a shell during compaction and hence allowed for a complete range of possibilities for the fracturing of the shell. Due to the unique microstructure of *Nautilus* shell, breakage in any of these three planes may produce different and characteristic fragments and therefore, all of these planes must be considered and included in an experimental design.

The experimental component of this section utilised an INSTRON static loading machine (as used in Currey & Taylor, 1974) (model 5566) and was operated with the assistance of the UOW Faculty of Engineering and Information Sciences. The experimental design involved placing a *Nautilus* shell on the stage of the INSTRON machine and bringing the upper plate down to the point where it freely supported the *Nautilus* shell without exerting a significant amount of force onto it. The INSTRON was then zeroed for load (N) and compressional distance (mm) before compression was initiated. Compression was set to 1 mm/minute and each experiment lasted until the shell had structurally failed and fragmented. The fragments were then collected and labelled with the specimen number and plane of compression. This process was repeated for each of the three shell specimens (one for each plane - dorsal/ventral, lateral and anterior/posterior). This ensured that each of these three planes of force exertion were tested to produce fragments that could be used as analogues for unworked fragments of *Nautilus* shell in later microscopic comparison.

While this project focuses on the physical features of the *Nautilus* shell and its fractography, there was also a significant ethnoarchaeological component to be considered. The history of *Nautilus* shell use provided an invaluable insight into the practices and techniques used to work the shell. This enabled a more refined experimental design for the process of working the *Nautilus* shell.

3.2 – Ethnoarchaeology

Ethnoarchaeology is generally defined as the study of present day cultural and ethnological features of a society through the examination of their material culture then using this information to gain clearer understanding of past societies based on archaeological recovery of their material culture (Stiles 1977). This study can be invaluable for the interpretation of archaeological artefacts as it allows cultural possibilities and solutions to be interrogated, which may enable details such as techniques of manufacture and cultural significance to be established. For this project, ethnoarchaeology is an important tool as the use of *Nautilus* shell is a rarely documented practice. Its current use in the Solomon Islands creates a rare opportunity to conduct an ethnoarchaeological study in order to better understand the practical implications as well as the cultural significance of using *Nautilus* shell as a raw material.

In order to understand the best ways to experimentally work the *Nautilus* shell, it was important to first look at the current and historical working of the *Nautilus*. This effectively provided a blueprint for the most likely techniques for the prehistoric working of *Nautilus* shell and enabled more accurate results to be obtained through the development of effective experimental design.

The ethnoarchaeological component of this study focused on the Solomon Islands. This is due to the fact that the Solomon Islands are one of the only places where *Nautilus* shell is still currently in use as a traditional raw material and has a long history of systematic and cultural use in the region (Burt 2009, p. 50). The long and continuous history of *Nautilus* shell working in this area provides a unique opportunity to perform field observations and discuss the use of *Nautilus* shell as a raw material with individuals who currently utilise the shell and who may have learned to work it before the introduction of modern tools.

A number of ethnoarchaeological techniques were employed in the field to obtain the data required for this project. These included interviews (recorded with a digital audio recorder), overt observations and physical recording in the form of photographs and video. A number of worked *Nautilus* offcuts were also collected for later examination under microscopy (see Chapters 6.2 and 7.2). The fieldwork component of this project was undertaken in Honiara, Solomon Islands, between 23/6/16 and 1/7/16. Previous connections established with the Solomon Islands National Museum enabled museum staff to assist in many capacities, mainly through locating individuals who either utilise *Nautilus* shell directly for use in craftwork to be sold to tourists, or who had considerable knowledge about the use of *Nautilus*.

Through the help of the Solomon Islands National Museum, a local craftsman named Peter Maepioh was identified as an individual with extensive knowledge regarding the traditional and current practices behind the shaping and inlaying of *Nautilus* shell. Peter has spent the past several decades working with *Nautilus* shell after learning the art from his uncle at a young age using basic tools.

An interview and working demonstration were conducted with Peter in order to answer several cultural and practical questions regarding *Nautilus* shell usage and its history in the Solomon Islands. This interview focused on topics such as the learning of working techniques, the change in these techniques over time, the change in tools used to work the *Nautilus* shell over time as well as the cultural and social importance of the working of *Nautilus* (see full interview transcript in Appendix 1). The working demonstration focused on the shaping and inlaying of *Nautilus* shell in a carved wooden ornamental statue. This involved the sawing of a strip of *Nautilus* shell followed by score-snapping and shaping of small pieces in order to fit inside a small groove carved into the wood (see Figure 3.1).

Figure 3.1: Worked *Nautilus* shell pieces being inlaid into a timber sculpture by Peter Maepioh in Honiara, Solomon Islands.

The demonstration into the current techniques for the working and usage of *Nautilus* was essential to gain further knowledge into the practical implications of working with such a unique material. As a craftsman with decades of experience, Peter was able to provide first-hand knowledge on the techniques and practices for working with *Nautilus* shell – explaining in detail techniques that worked, those that did not, and why. While modern, simple tools (such as a handsaw and metal files) were used by Peter, it is clear that a number of different tools and materials would have been used in prehistory. When Peter learned this craft, he was taught with old, handmade tools – much like those that would have been used in centuries past. For this reason, the experimental working of *Nautilus* shell was conducted using a range of natural materials accessible to the inhabitants of Gebe Island in the distant past.

A semi-structured interview was also conducted with Patricia George – the curator of the Solomon Islands National Museum shop. This interview focused on the variety of styles of *Nautilus* shell working and their origins throughout the Solomon Islands. As a culturally significant craft, *Nautilus* shell working has developed unique styles based on geographic distribution, with a number of these styles being referred to based on their place of origin (such as Western Province style or San Cristobal style (Meyer 1995, p. 405). A full transcript of this interview can be seen in Appendix 2.

3.3 – Experimental working

The experimental working phase of this project involved creating an assemblage of *Nautilus* shell fragments that had been worked using a range of different materials and techniques. This assemblage could then be used for comparison with the archaeological samples recovered from Golo Cave, with microscopic analysis showing any similarities/differences in surface wear patterns or microstructure. This methodology involved collecting the most likely materials that could have been used for working the Golo Cave samples and using them to experiment on current specimens of *Nautilus* shell. The materials selected for working the *Nautilus* shell included: fine-grained basalt, chert, basaltic grinding block, vesicular basalt blocks, branched coral and sea urchin spines. Considering both *Nautilus* body whorl and septal wall fragments were recovered at Golo Cave, each experiment was replicated on body whorl and septal wall. This was a necessary step as the microstructure and properties of body whorl and septal wall are significantly different (refer to Chapter 2). The experimental process was conducted systematically and with a focus on not only the materials used, but also the number of gestures used to perform each experiment and the angle/direction of working. Weston et al. (2015) established the conceptual framework for this methodological technique, with Szabó and Koppel (2015) piloting the highly structured and analytical technique on samples of worked *Scutellastra flexuosa* limpets from Golo Cave.

Biology student Chelsea Flood conducted a number of *Nautilus* breakage experiments involving the percussion of whole *Nautilus* samples using a number of items including a hammerstone and a wooden mallet. These whole samples were either percussed using freehand or anvil percussion to generate fragments of shell. These fragments were then selected for use in these experiments. These *Nautilus* specimens were all mature, as was most likely the case with any shell worked in Golo Cave due to the rarity of juvenile specimens found in nature (Tanabe & Uchiyama 1997; Cochran et al. 1981). Specific fragments were chosen based on size. The samples chosen for working were generally between 2 cm^2 and 4 cm^2 as these were the easiest fragments to hold and work.

The experiments were in two distinct categories: score (or score-snap) experiments, and abrasion experiments. The score experiments used flakes of fine-grained basalt and chert in order to score the nacreous side of the body whorl, and the concave side of the septal wall. With a palm mid-rib used as a guide, each lithic material (basalt and chert) was used to score the body and septal wall with 50 and 100 gestures. The score-snap experiments also followed this exact procedure, however, the sample was snapped along the scoring line to produce two smaller fragments afterwards.

The abrasion experiments involved taking both body whorl and septal wall fragments and abrading an edge using one of the following: a basalt grinding block (a large, flat stone to abrade the edge of the fragment at a 90-degree angle), basalt blocks (smaller and vesicular in nature to abrade the edge of the fragment at a 45-degree angle), branch coral (*Acropora* sp.), sea urchin spines (*Heterocentrotus mamillatus*), and ray skin (*Aptychotrema rostrata*). The body whorl fragments were abraded along one edge, with contact running perpendicular to the outermost layer of the shell (prismatic side). The septal wall fragments do not exhibit a layered structure and, as such, were abraded without a fixed orientation. Each material was used to abrade the body whorl and septal wall with 20, 50 and 100 gestures each. This repetition with varying gestures sought to provide a clear result of the traces of working *Nautilus* shell regardless of the intensity of abrasion.

The conclusion of the working experiments was followed by a microscopic analysis of the experimentally worked samples, the unworked INSTRON samples and the archaeological Golo Cave fragments using a Dino-Lite digital low-power microscope (Dino-Lite Edge digital microscope, AM4815 Series). The worked samples were photographed under low-powered magnification to examine for diagnostic traces left by each material throughout the working experiments. This process examined the worked edges of the samples and photographs were then taken of any notable features (worked surfaces, residue, striations, fracture surfaces etc.). The INSTRON samples were examined under the Dino-Lite to show the edge structures of a naturally fractured fragment (analogous to a fragment generated through compaction) without working. The archaeological fragments were also examined under low-power microscopy to identify any potentially worked samples as well as determine which samples remained in a condition that could be accurately compared to the assemblage of experimental samples.

A number of samples were then chosen for further examination under a high-powered scanning electron microscope (SEM). The criteria for the selection of these pieces were based on their relevance to the Golo Cave archaeological samples (i.e. if they were derived from the same part of the shell as found in the Golo Cave samples) as well as their degree of diagnostic working traces. Out of the 55 worked samples, seven fragments met these criteria and were hence selected for further analysis using the SEM. Seven of the twelve *Nautilus* fragments recovered from Golo Cave were found to be in a suitable condition and/or contained features that required closer examination and were also selected for SEM analysis. In order to gain a better understanding of the fracture patterns on an unworked sample, a fragment generated through INSTRON compression in the dorsal/ventral plane (fragment Nab-004a) was selected as it contained each of the three most commonly observed fractured edge types found on the INSTRON samples (straight, lamellar and overhanging). Finally, an offcut sample from the fieldwork demonstration conducted by Peter Maepioh, which had been worked using modern tools (a knife, round file and straight file), was chosen for SEM analysis. This gave a clear indicator of the traces left by modern tools and the distinct difference between lithic- and steel-based score-snap patterns.

The samples selected for SEM analysis were taken to the UOW Innovation Campus and examined using a JEOL JSM-6490LA scanning electron microscope. Samples were not coated for the SEM analysis (as is usually procedure from samples examined under SEM) as the archaeological fragments from Golo Cave are culturally and historically significant and could not be altered in the manner required by coating. This would mean that coating of the INSTRON or experimentally worked *Nautilus* would make the samples incomparable with the uncoated Golo Cave fragments. For this reason, all fragments were uncoated and imaged using low voltage (15kV) and low-pressure (1Pa-34Pa) conditions (see individual figures for specific condition details). Once SEM images of the INSTRON, experimentally worked and Golo Cave *Nautilus* shell fragments had been obtained, these were cross-referenced to identify any similarities and patterns found between them. This process enabled the interpretation of the fragments in the context of identifying archaeological fragments from Golo Cave as being either worked by humans or not worked by humans.

Chapter 4 – Analysis

This chapter will focus on the specific procedures followed to execute the methods described in the previous chapter. These procedures will be examined in the following order: INSTRON experiments, ethnoarchaeological field work in the Solomon Islands, experimental working of modern *Nautilus* fragments and examination of archaeological samples from Golo Cave.

4.1 – INSTRON

INSTRON experiments were carried out on three *Nautilus belauensis* shells in order to obtain fragments that could be used to study the nature of naturally fractured, unworked edges and to note broad patterns of fragmentation. These specimens were subjected to compressional forces in an INSTRON static-loading machine (model 5566) with a possible loading range of 2N – 10kN of force. The machine was set to compress the shells at a rate of 1 mm/minute and was zeroed for both load (N) and compressional distance (mm) before the commencement of each experiment. Zuschin and Stanton (2001) noted in a similar experiment that the strength of a shell under compressional force was more closely related to shell thickness than size. Zuschin et al. (2003) further commented on the factors affecting shell strength, listing microstructure and the degree of organic matrix found in the shell as key factors. The unique microstructure of *Nautilus* (Clark 1999) and the presence of a substantial organic matrix (Checa et al. 2011) contribute to the high strength of *Nautilus* shell and make it possible for the organism to withstand the high pressures associated with living at depth. Each INSTRON run was concluded when the specimen being compressed had structurally failed resulting in the production of fragments and/or severe cracking.

Nab-4

Shell Nab-4 was compressed in the dorsal/ventral plane (Figure 4.1). Cracking could be heard as the compression increased. This sound was concurrent with the patterns in the graphed results, as each crack showed a drop in the load on the shell (Figure 4.2). Significant failure occurred at around 573N, 70 seconds into the experiment. An audible crack as well as a clear decrease in load (N) on the graph was noted. This failure produced several fragments (Figure 4.3), thus concluding the experiment.

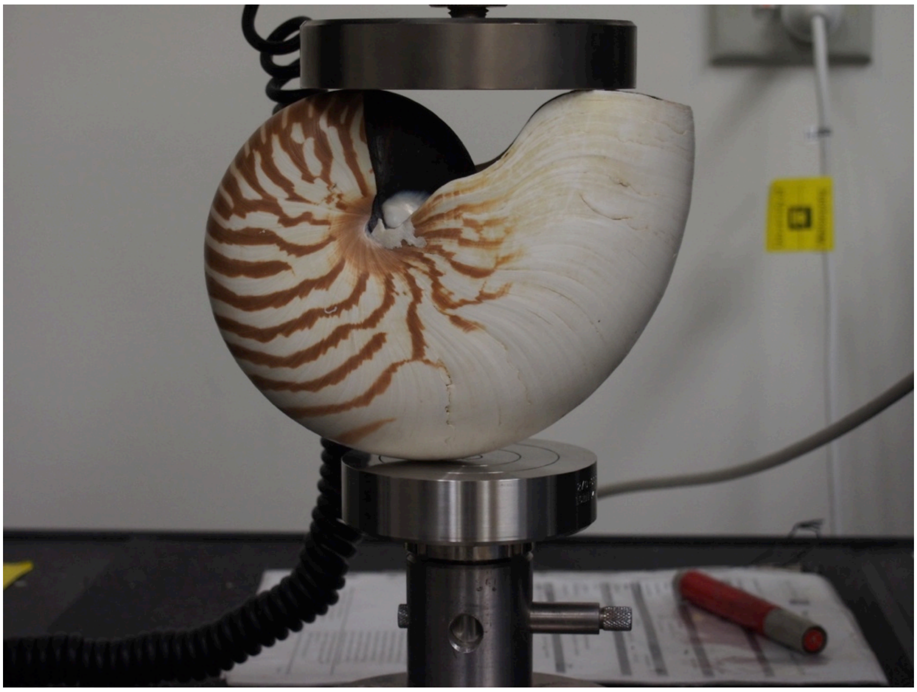

Figure 4.1: Nab-4 on the INSTRON machine in the dorsal/ventral plane.

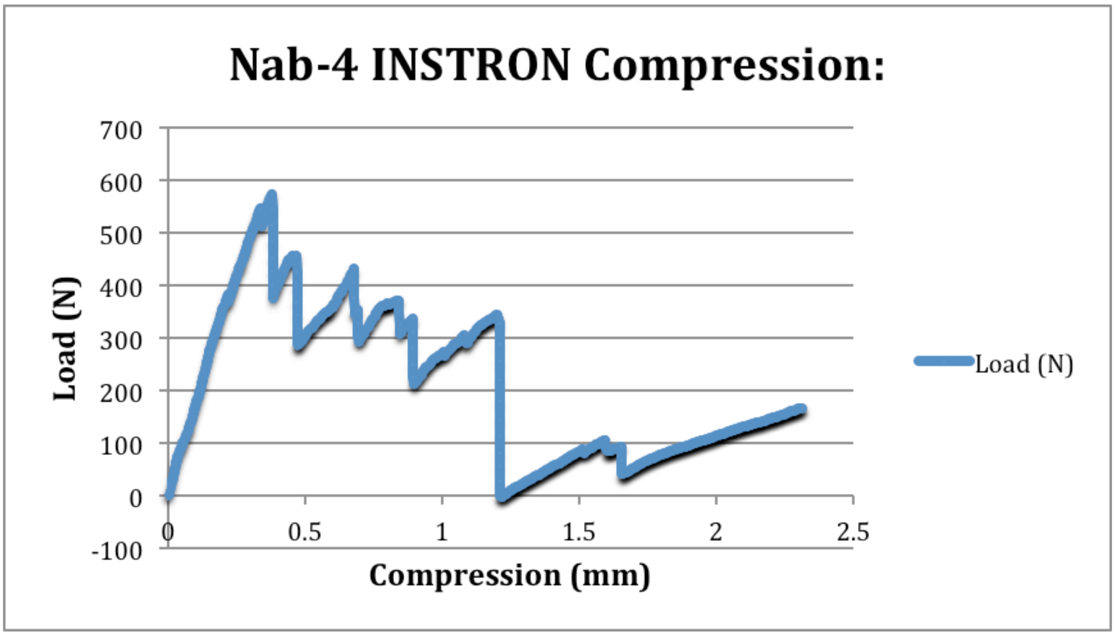

Figure 4.2: Graph showing the load and compression on Nab-4 in the dorsal/ventral plane.

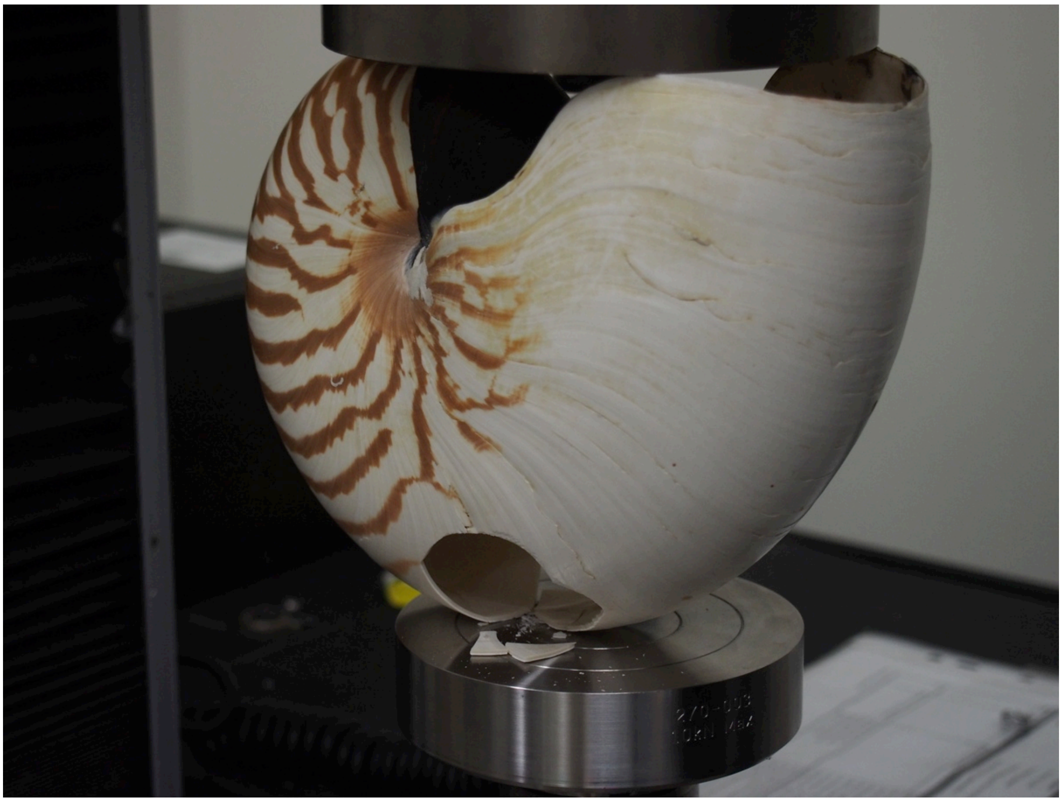

Figure 4.3: Fractured *N. belauensis* Nab-4 on the INSTRON machine (dorsal/ventral plane).

Nab-5

Nab-5 was compressed in the lateral plane (Figure 4.4). As with Nab-4, slight cracking could be heard as the experiment progressed, however, there were no notable corresponding reductions in load noted on the graph when these occurred (Figure 4.5). The shell appeared to be flexing significantly in this plane before failure occurred at around 300N, approximately 78 seconds into the experiment. This fracturing produced one main fragment and significant cracking throughout the shell (Figure 4.6).

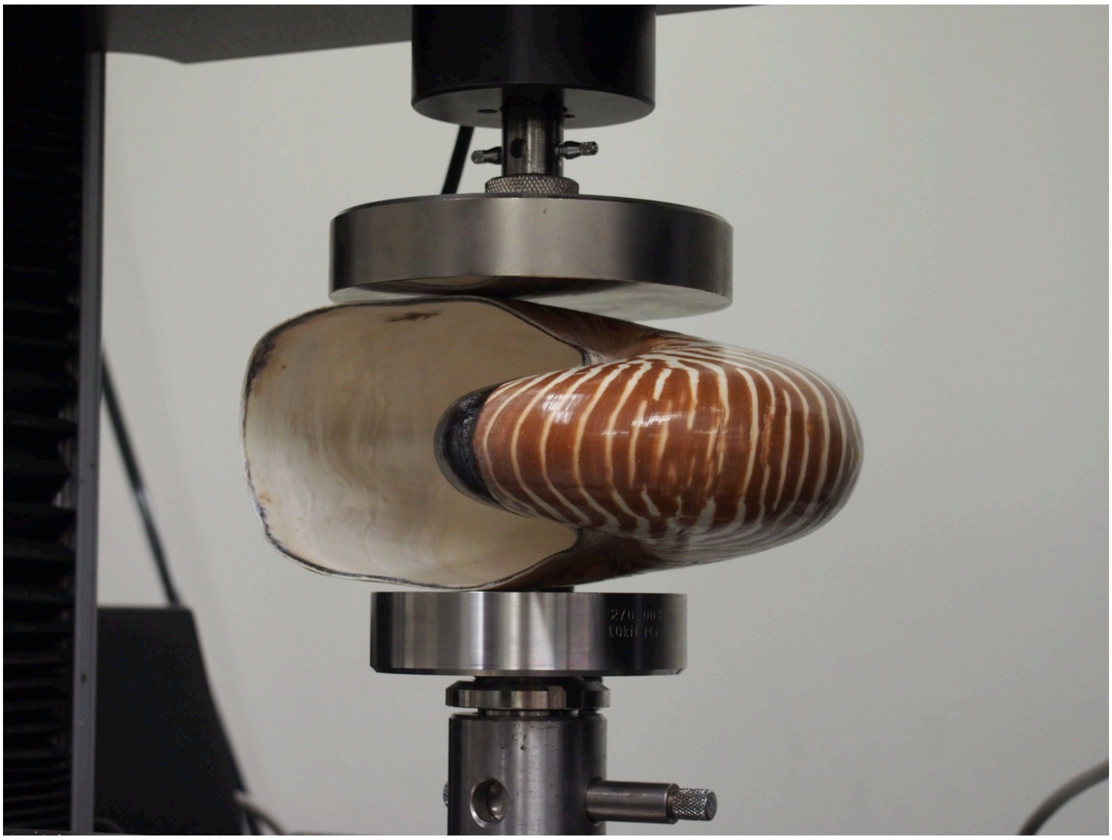

Figure 4.4: Nab-5 on the INSTRON machine in the lateral plane.

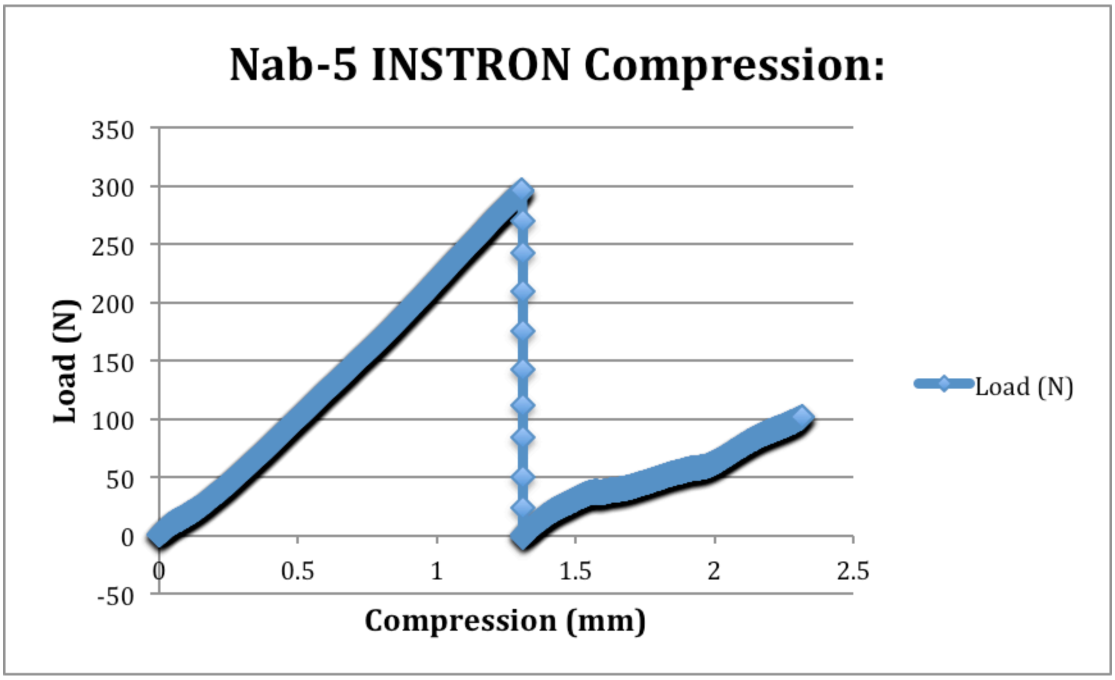

Figure 4.5: Graph showing the load and compression on Nab-5 in the lateral plane.

Figure 4.6: Fractured *N. belauensis* on the INSTRON machine in the lateral plane.

Nab-19

Two failed attempts were made to compress Nab-19 in the anterior/posterior plane. In these attempts, the shell was being physically held in place by hand. As the compression was initiated, however, a lack of traction between the shell and the INSTRON plates meant that the shell slipped progressively and the load never increased above 12N in either of these two failed attempts (an insignificant load when compared to the Nab-4 and Nab-5 samples). For this reason, the shell was affixed to the INSTRON stage and plate using 3M VHB double-sided tape. With the shell securely fixed in place (Figure 4.7), the third attempt yielded a successful result, with the shell experiencing a number of significant cracks before failing at around 140N at approximately 458 seconds (Figure 4.8). This resulted in the significant fracturing of Nab-19, with one large fragment and several smaller fragments produced (Figure 4.9).

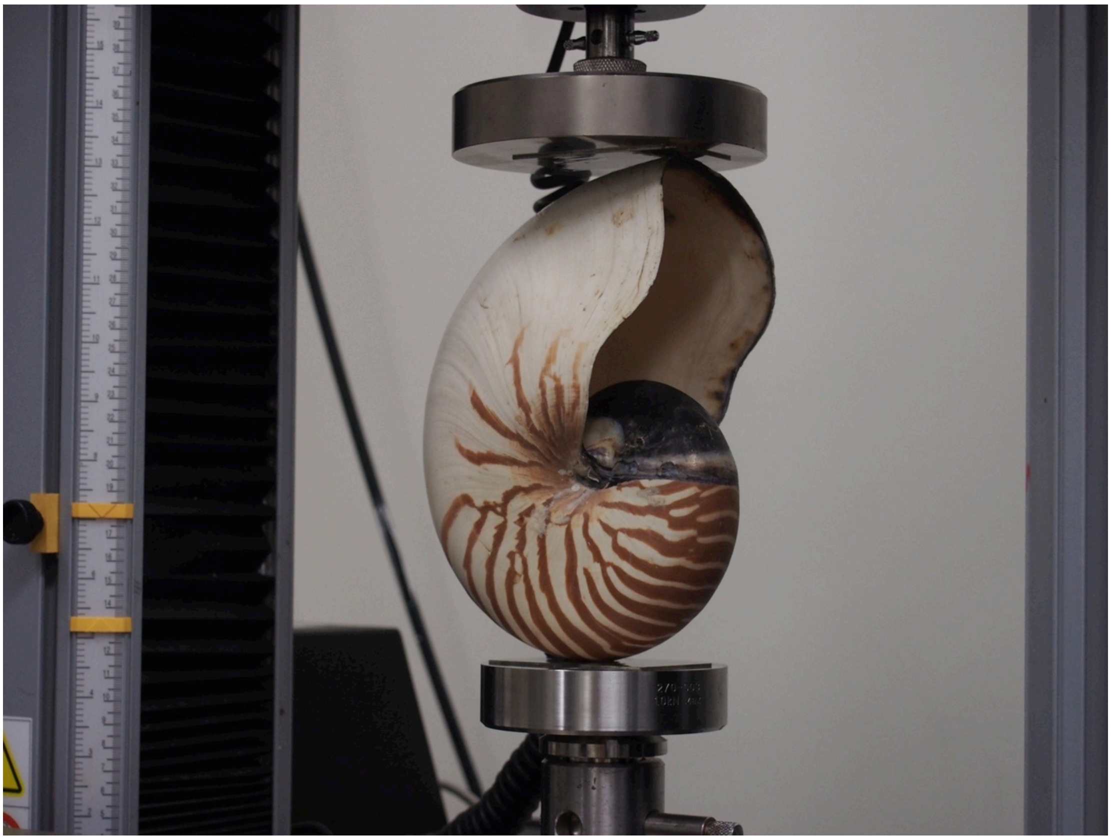

Figure 4.7: Nab-19 on the INSTRON machine in the anterior/posterior plane.

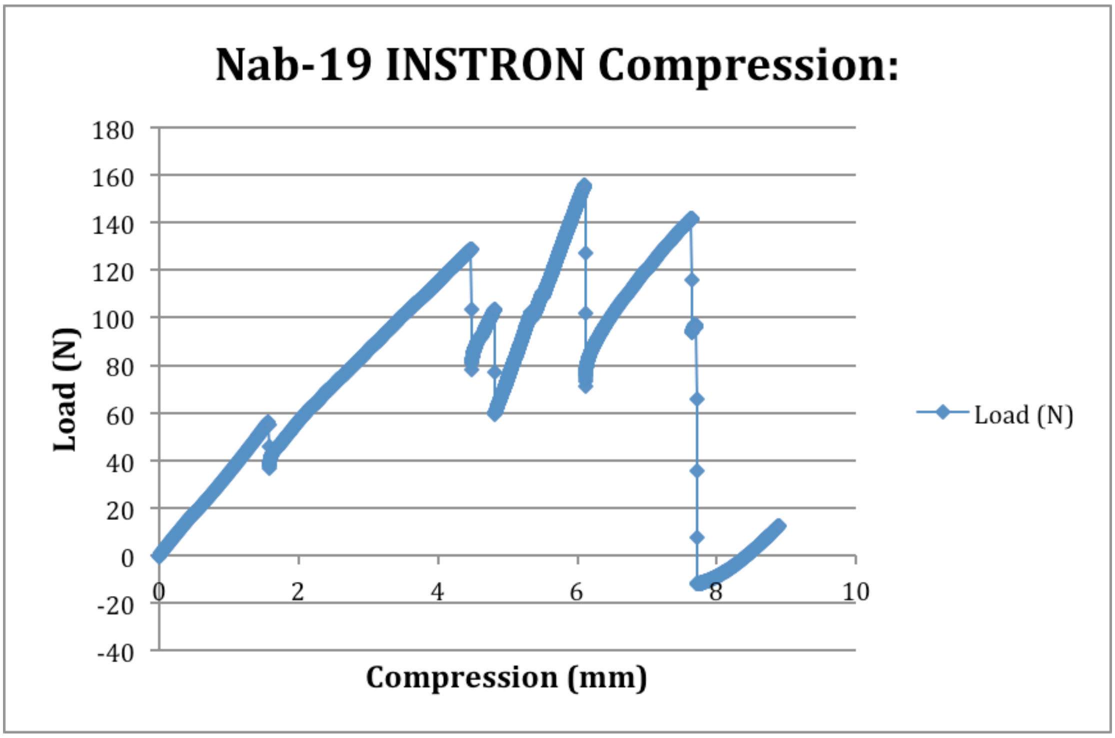

Figure 4.8: Graph showing the load and compression on Nab-19 in the anterior/posterior plane.

Figure 4.9: Fractured *N. belauensis* on the INSTRON machine in the anterior/posterior plane.

4.2 – Ethnoarchaeology

In order to better understand the use of *Nautilus* shell in a practical and cultural sense, an ethnoarchaeological component of this project examined the use and importance of *Nautilus* shell in the context of the Solomon Islands. The fieldwork component of this study was focused around Honiara, Solomon Islands, where craftspeople from all across the nation congregate in order to sell their craftwork to tourists that visit the capital (Revolon 2014, p. 124). Much of the craftworking takes place in and around Honiara within diasporic communities, so Honiara is not simply an end-point marketplace.

Through contacts at the Solomon Islands National Museum, two individuals were identified as having significant knowledge of both the practical skills and techniques required to work the *Nautilus* shell, as well as the cultural significance of this shell, both in present day and historical contexts. To better understand the processes and importance of *Nautilus* shell working, two semi-structured interviews and one workshop demonstration were conducted. These were undertaken with the approval of the University of Wollongong Human Research Ethics Committee (HREC) (ethics number HE16/231).

The first was a verbal interview with Peter Maepioh, a local craftsman with decades of experience in carving sculptures and inlaying them with *Nautilus* shell in the style of Western Province inlay. Originally from Morovo Lagoon on the island of New Georgia, Western Province, Peter learned to work with *Nautilus* shell at a young age. Being taught the craft by his uncle, Peter was able to produce craftwork using basic tools, such as steel knives and rough leaves (for abrasion). Being a traditional cultural practice, Peter was also taught the meanings behind the sculptures, the gods they represented and how they were most appropriately used. The elements of this interview most pertinent to this thesis are presented in Chapter 5 of this thesis.

Peter was also able to give a demonstration of *Nautilus* shell working at his home workshop in Honiara. Showing the process of taking a whole *Nautilus* shell all the way through to a finished piece of art in the form of shell inlay gave great insight into the techniques used for working with such a unique material. This demonstration became important for adapting the methodology of this project to best reflect some of the practical working techniques demonstrated by Peter. It also provided clarification on the most, and least, appropriate methods of working *Nautilus* and the technical reasons behind these judgements. A full description of his working processes can be found in Chapter 5 of this thesis.

The second interview conducted was with Patricia George, curator of the Solomon Islands National Museum shop. As shop curator, Patricia has an extensive knowledge of the varying styles and traditions of *Nautilus* shell working from across the Solomon Islands as well as a deep understanding of shell valuables and their role in the region in general. She interacts with craftspeople from across the Solomon Islands one-on-one and is well versed on pan-local traditions as well as internal diversity.

Defined spheres of interaction within the Solomon Islands has meant that various practices and traditions of working *Nautilus* shell have become unique to certain regions, leading to styles being referred to by the area in which they originated, such as Western Province style or San Cristobal style (Meyer 1995, p. 405). This geographic separation of styles was well understood by Patricia, making her insight into the various styles invaluable for understanding the cultural traditions of *Nautilus* shell use.

All interviews conducted were recorded using a digital audio recorder. Photographs were taken of the items being shown in these interviews and demonstration using a Panasonic Lumix TZ70 digital camera and a Pentax K1000 35mm film camera. Video recording was also taken of Peter Maepioh's workshop demonstration using a Panasonic Lumix TZ70. The audio recordings of the interviews were then used to make a detailed transcript (as seen in Appendices 1 and 2).

4.3 – Experimental working

The experimental working stage of this project involved creating a collection of modern *Nautilus belauensis* shell fragments and working them with a variety of materials and using a range of techniques. The *Nautilus* shells used in this state were all mature specimens, with very little variation occurring in the structure of *Nautilus* shells once they have progressed beyond the early (embryonic) stage (Tanabe & Uchiyama 1997). This experimental design was aimed at creating a wide selection of traces on the surface of the shell fragments for later comparison with the archaeological fragments recovered at Golo Cave.

Generation of fragments

Biology student and zooarchaeology intern Chelsea Flood generated the fragments of two out of the three *Nautilus* shells used for the experimental working section of this project (Nab-001, Nab-007) during fracturing experiments conducted in 2014-2015.

Initial reduction of shell Nab-001 was achieved through freehand percussion using a mallet-like stick. The impact was centred at approximately halfway around the body whorl of the shell. Further reduction was performed using the same technique on a number of the larger fragments in order to increase the number of usable samples. In total, fourteen major fragments were generated (with a number of minor fragments ranging from around 1-10 mm^2 being unusable for experimentation due to their size).

Initial reduction of shell Nab-007 was achieved through anvil percussion using a rounded hammerstone. The impact was centred at approximately half way around the body whorl of the shell. Approximately twenty-one major fragments were generated through this technique.

Initial reduction of shell Nab-003 was achieved through freehand percussion using a mallet-like stick. The impact was centred at approximately halfway around the body whorl of the shell. A number of larger fragments were then re-percussed in order to generate a greater number of usable samples.

Initial reduction of shell Nap-000 was achieved through freehand percussion using a mallet-like stick. The impact was centred at approximately halfway around the body whorl of the shell. The same technique was used to percuss some of the larger samples in order to obtain a larger number of usable fragments.

Scoring experiments

The first experiments conducted involved scoring the nacreous internal surface of fragments of *Nautilus* shell. This was done using two different lithic materials: basalt and chert. In order to acquire a comprehensive sample of possible traces for the working of the *Nautilus* shell, basalt and chert were used to score both the body whorl and septal wall of the shell using 50 and 100 gestures for each material. Some septal wall fragments selected for these experiments contained the siphuncle tube – evolved to empty the chambers of liquid and fill them with gas during the animal's life (Ward et al. 1981). These structures were avoided during score-snapping of septal wall fragments, as they do not represent the main form of the septal wall.

The flakes of chert used to score the samples were approximately 2 cm^2 in size and around 1-5 mm thick and had been generated through freehand hardhammer percussion from a large piece sourced from the School of Earth and Environmental Sciences geology bulk collection. For each gesture, a sharp edge was used and contact between the chert shard and shell fragment was kept at a consistent pressure. Each gesture was performed in the same direction – a single-stroke cutting motion as opposed to a back and forth 'sawing' motion. The flakes of fine-grained basalt used to score the *Nautilus* fragments were approximately 2 cm^3 and featured several sharp and pointed edges. These edges were used to score the shell, however, due to the irregular shape of the basalt fragments, some score marks were generated to the side of the main score line. This appeared to have no effect on the subsequent snapping of the shell fragment.

In order to keep the score lines straight and consistent, the mid-rib of a palm frond was used as a guide. This palm mid-rib was laid across the fragment and scores were initiated at the edge of the shell fragment with the trajectory of the score tracing the palm mid-rib until termination at the other edge of the fragment. An example of this technique can be seen in Figure 4.10 below.

Figure 4.10: Chert used to score a body whorl fragment with palm mid-rib used as a guide.

Score-snap experiments

The second phase of experimentation involved scoring the fragments of *Nautilus* and then snapping them along the score line. These experiments repeated the same procedure and technique as the score experiments listed above (both chert and basalt were used to score the body whorl and the septal wall with 50 and 100 gestures each), with the fragment then being snapped along the score line using gloved hands. Breakage along the score line occurred successfully in all but one sample. Experiment 12a involved scoring a sample of body whorl fragment with chert for 100 gestures. Upon initiating the snap, the breakage deviated from the score line approximately half way along the fragment, with a secondary breakage line running perpendicular to the score line resulting in three fragments in total. This experiment was then repeated with another fragment in order to generate a score-snap result.

Abrasion experiments

The next experiments conducted involved abrading the edges of *Nautilus* shell fragments using a variety of materials to generate a worked edge with potentially diagnostic traces. The materials utilised for this phase of experimentation included rounded vesicular basalt abrasion blocks, a flat vesicular basalt grinding block, *Acropora* sp. branching coral, *Heterocentrotus mammillatus* sea urchin spines and ray skin (*Aptychotrema rostrata*). The abrasion experiments were conducted systematically with each material being used to abrade *Nautilus* body whorl and septal wall fragments using 20, 50 and 100 gestures. As with the score experiments, the gestures for working the shell were only executed in one direction, not in a back and forth motion. On the body whorl fragments, the gestures were performed on the edge of the outermost prismatic layer of the shell. The septal wall fragments do not exhibit compound microstructural layering and therefore, working of these fragments could be conducted on either side without affecting the results. The basalt abrasion blocks were approximately 2 cm^3 with vesicles throughout. They were utilised by drawing the rock across the shell fragment perpendicular to the edge at an approximate 45-degree angle. This technique can be seen in Figure 4.11 below. The working generated a very fine dust of disintegrated shell grit.

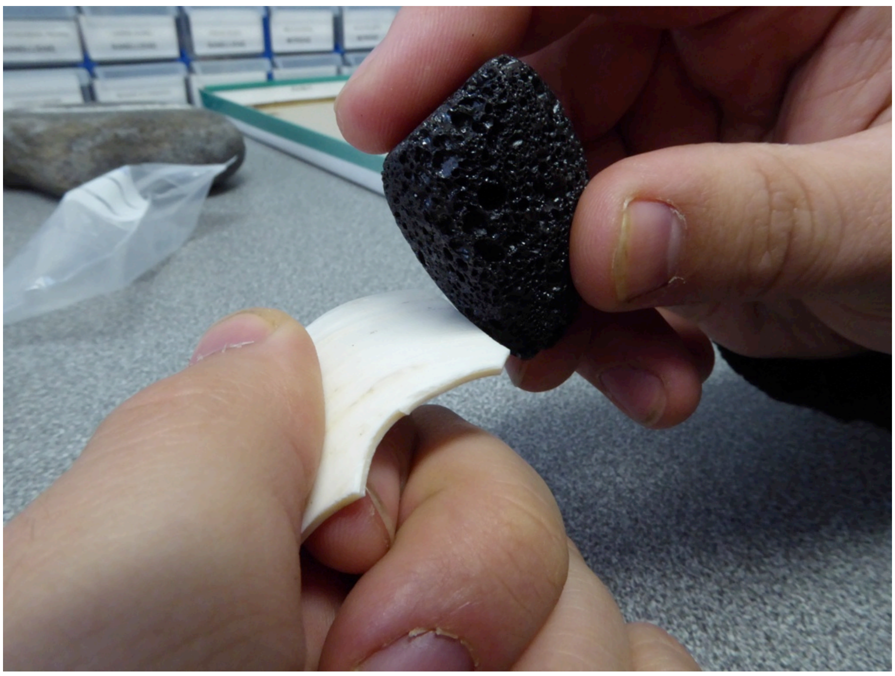

Figure 4.11: Basalt abrasion block being used to abrade the edge of a body whorl fragment.

The flat grinding block was used to work the flat edge of the shell by holding the shell at a 90-degree angle to the grinding block and dragging it in one direction for each gesture. This technique would generate a different working pattern to the other abrasion experiments, which focused on the angled working of the prismatic layer as opposed to the flat edge of the shell with all layers exposed at once. This technique is demonstrated in Figure 4.12 below.

Figure 4.12: Grinding block being used to abrade the edge of a *Nautilus* shell fragment.

Acropora sp. branching coral was also used to work the edge of the shell fragments. The branched coral piece was approximately 8-10 cm long and 1 cm thick. As with the basalt abrasion blocks, the outer prismatic layer was worked by drawing the branched coral in a downward motion at a 45-degree angle to the edge of the shell. With each gesture, a fine white powder was produced. This appeared to be the delicate outer surface of the calcium carbonate branching coral rather than the *Nautilus* shell, although the *Nautilus* shell was likely also undergoing a small amount of abrasion. This technique can be seen in more detail in Figure 4.13 below.

Figure 4.13: *Acropora* sp. branching coral being used to abrade the edge of a *Nautilus* shell fragment.

Heterocentrotus mammillatus sea urchin spines were used as abrasive material for these experiments. The spines used were approximately 7 cm long and around 8 mm thick. The abrasion was conducted by drawing the urchin spine in a downward motion at a 45-degree angle to the edge of the shell. Due to the ridged nature of the spine, slight rotation was also performed during the gesture to increase the abrasive quality of the material. Throughout this stage, the *Nautilus* shell appeared to be causing slight damage to the urchin spine with minor abrasion occurring on the outer edge of the spine. This may indicate that the shell is harder than the spine and any abrasion on the *Nautilus* shell from this experiment would be expected to be relatively minor. The technique of *Heterocentrotus mammillatus* abrasion can be seen in Figure 4.14.

Figure 4.14: *Heterocentrotus mammillatus* spine being used to abrade the edge of a *Nautilus* shell fragment.

Lastly, ray skin (*Aptychotrema rostrata*) was used to abrade the samples. This is a coarse, sandpaper-like material, similar to sharkskin that Peter Maepioh explained would have been used for abrasion before the time of modern tools. This skin was first dried for 48 hours before being used as an abrasive in this experiment. The skin was held at a 45-degree angle to the shell fragment and gestures were conducted in a single direction (see Figure 4.15 below). Throughout the experiment, the *Nautilus* shell appeared to be causing damage to the ray skin, with the coarse outer layer of the skin being abraded down. The shell itself also appeared to sustain minor abrasion traces, but very little debris was generated – unlike the experiments involving the lithic abrasion materials – which caused a significant amount of the shell fragment itself to be notably abraded away during the experiment.

Figure 4.15: *Aptychotrema rostrata* skin being used to abrade a *Nautilus* shell body whorl fragment.

The process of experimentally working the shells aimed to create an assemblage of working traces to be compared with Golo Cave archaeological fragments through low- and high-power microscopy. The Golo Cave fragments that form the basis of this project will be examined in the following section to show their general structure and likely age range.

4.4 – Golo Cave Fragments

Bellwood and colleagues excavated the *Nautilus* shell fragments examined in this project from Golo Cave on Gebe Island, eastern Indonesia in 1994 and 1996 (Bellwood at al. 1998). The fragments were recovered from depths ranging from 30 to 205 cm below surface and showed varying degrees of taphonomic alteration. The relative ages of these fragments have been established through dating of marine shells found throughout the sequence, with a range of ages given for the *Nautilus* shell fragments in Table 4.1 below.

These dates were taken from Bellwood et al. (1998) and Szabó and Koppel (2015). For sample depths with no known age, a range was given based on the next known date above and below the depth of the sample in question.

Table 4.1: Square, depth and ^{14}C age (BP) of Golo Cave *Nautilus pompilius* fragments.

Sample #:	Square:	Depth (cm):	^{14}C age BP:	SEM?:
GC-001	M4	30-35	<3255	Y
GC-002	M4	40-45	3255-3680	Y
GC-003	M5	50-55	7629 - 7893	N
GC-004	M5	50-55	7629 - 7893	Y
GC-005	M5	60-65	3230 ± 80 - 10210 ± 60	N
GC-006	M5	95-100	10210 ± 60	N
GC-007	M5	95-100	10210 ± 60	Y
GC-008	M4	140-145	7400 ± 10 - 29390 ± 190	N
GC-009	M4	175-180	29390 ± 190 - 30960 ± 190	Y
GC-010	M4	175-200	29330 ± 190 - 30960 ± 190	N
GC-011	M4	195-200	30960 ± 190	N
GC-012	M4	200-205	28740 ± 474	Y

The following Figures (4.16-4.27) show the fragments recovered from Golo Cave in their entirety. These samples were all examined under Dino-Lite microscopy and some under SEM microscopy (as seen in Chapters 6 and 7). These images were taken using a Panasonic Lumix TZ70 digital camera.

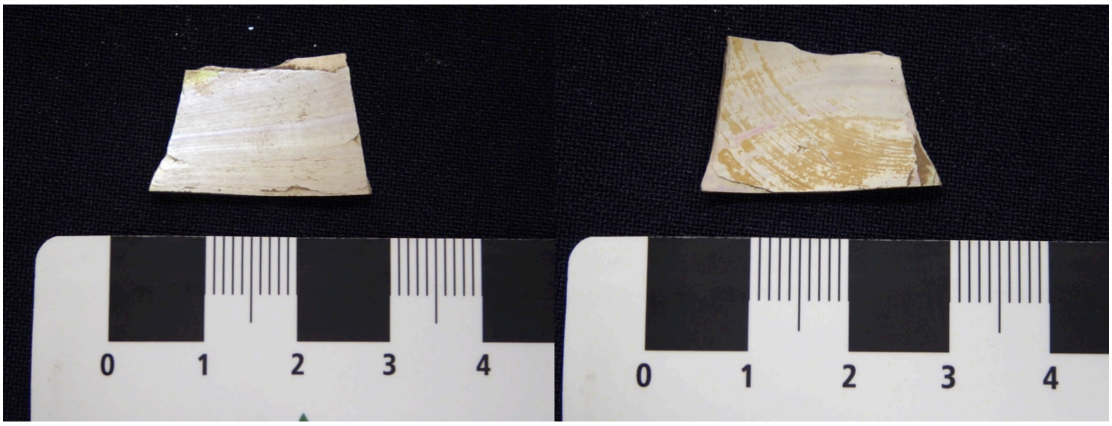

Figure 4.16: GC-001 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 30-35 cm depth.

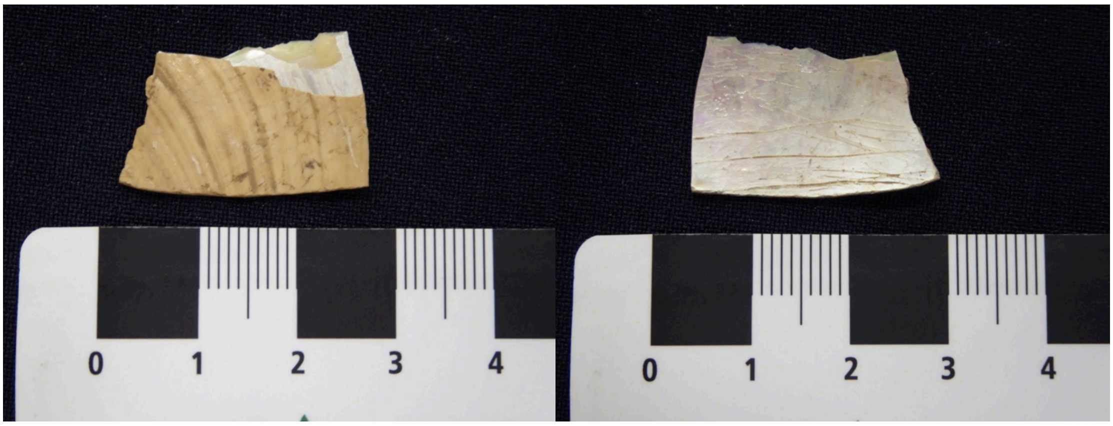

Figure 4.17: GC-002 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 40-45 cm depth.

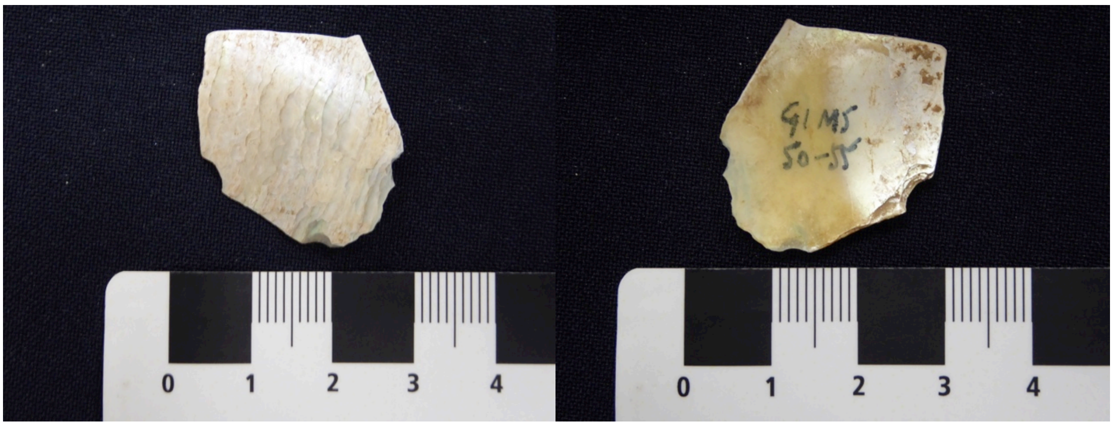

Figure 4.18: GC-003 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 50-55 cm depth.

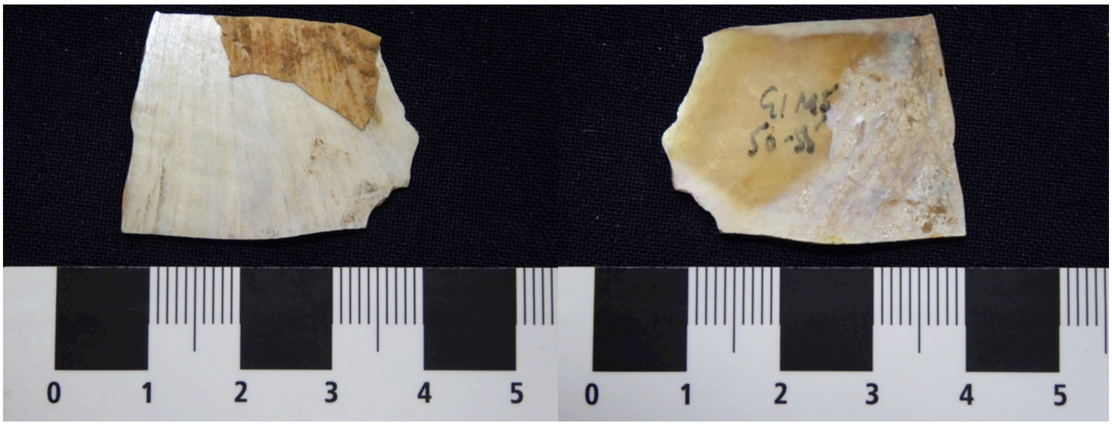

Figure 4.19: GC-004 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 50-55 cm depth.

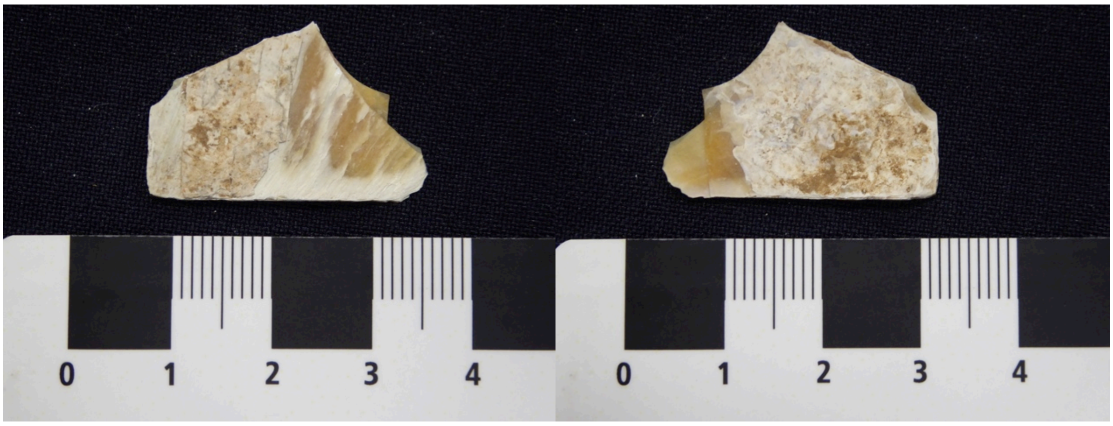

Figure 4.20: GC-005 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 60-65 cm depth.

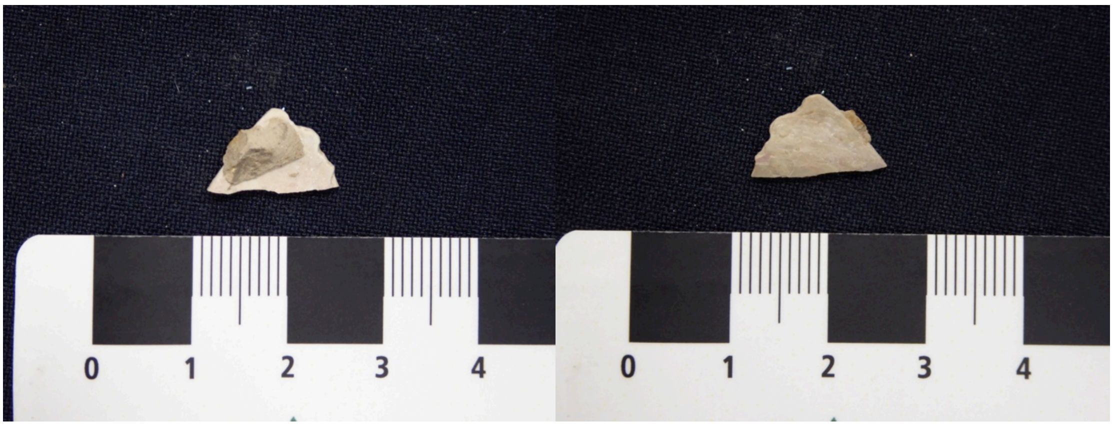

Figure 4.21: GC-006 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 95-100 cm depth.

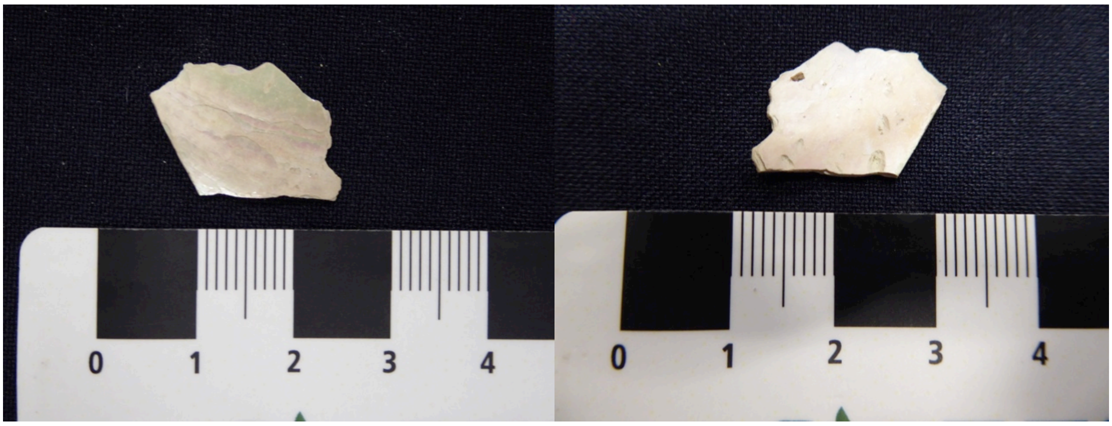

Figure 4.22: GC-007 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 95-100 cm depth.

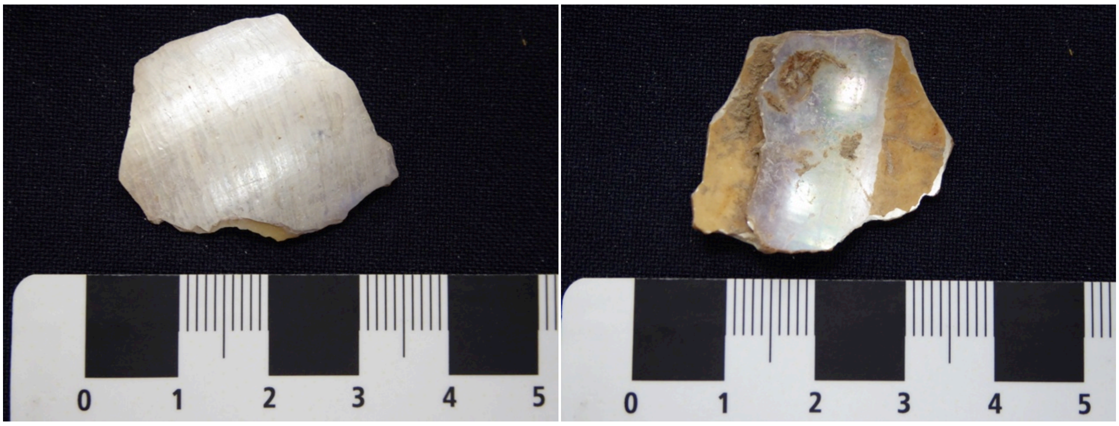

Figure 4.23: GC-008 – *Nautilus pompilius* body whorl fragment with remnants of a septal wall recovered from Golo Cave, 140-145 cm depth.

Figure 4.24: GC-009 – *Nautilus pompilius* septal wall fragment with complete siphuncle hole recovered from Golo Cave, 175-180 cm depth.

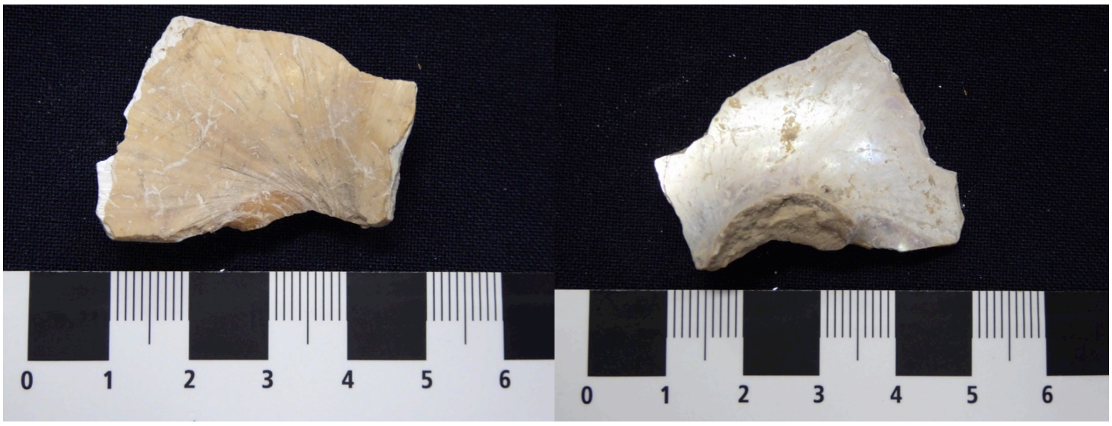

Figure 4.25: GC-010 – *Nautilus pompilius* body whorl fragment at umbilicus recovered from Golo Cave, 175-200 cm depth.

Figure 4.26: GC-011 – *Nautilus pompilius* body whorl fragment recovered from Golo Cave, 195-200 cm depth.

Figure 4.27: GC-012 – burnt *Nautilus pompilius* septal wall fragment with complete siphuncle hole recovered from Golo Cave, 200-205 cm depth.

The approximate visual estimates of the edge types, as determined under low-power microscopy, for these twelve fragments from Golo Cave are presented in Table 4.2 below.

Table 4.2: Estimated relative % of edge types for Golo Cave fragments 1-12.

Sample:	**Straight:**	**Lamellar:**	**Overhang:**
GC-001	75	15	10
GC-002	80	5	15
GC-003	50	40	10
GC-004	95	5	0
GC-005	60	25	15
GC-006	40	45	15
GC-007	35	50	15
GC-008	75	25	0
GC-009	95	0	5
GC-010	60	35	5
GC-011	100	0	0
GC-012	80	10	10

The results of low- and high-powered microscopy conducted on these, as well as INSTRON and experimentally worked *Nautilus* samples, will be examined in Chapters 6 and 7.

Chapter 5 – Ethnoarchaeology Results

The ethnoarchaeological fieldwork component of this project was conducted in Honiara, Solomon Islands. This involved two semi-structured interviews as well as a workshop demonstration by a local craftsman. The aim of this section of the project was to gain a better understanding of the history and significance of *Nautilus* shell working in the Solomon Islands to better understand the general practice of *Nautilus* shell working and the cultural significance it may have held throughout the region in prehistory.

The first interview was conducted with Peter Maepioh (Figure 5.1), a craftsman living and working in Honiara. Peter carves sculptures and ornaments out of timber and then uses a number of techniques to cut and shape *Nautilus* shell for use as inlay in the wooden sculptures. The interview with Peter was able to reveal important information about not only the practical aspects of working with *Nautilus* shell, but also the cultural importance of *Nautilus* as a raw material for artefact production and its significance in terms of community and cultural identity.

Figure 5.1: Craftsman Peter Maepioh at his home in Honiara, Solomon Islands, holding an unfinished *Totoisu* carving.

During the interview, Peter was asked how he first learned to work with *Nautilus* shell. Peter explained that his uncle taught him the process from a young age. His uncle had sons of his own, and Peter was not the oldest of his siblings, which raised the question of why Peter was chosen to learn the art of *Nautilus* shell carving when there were other family members who could have also been chosen. Peter explained that in the Solomon Island culture, all members of his family had the same right to learn the craft, it was up to his uncle to decide whom it would be taught to. On being selected by his uncle, Peter said:

> *"…he have* [sic] *his own children and his second brother have* [sic] *children, boys and girls, and my dad is very young, he's last one in the family but they give it to me. And I have my first brothers, maybe four big brothers, but he didn't give to them. He called and said 'Peter you take over my work and I give it to you'"*

When asked what tools he was first taught with, Peter said that the early tools were all hand-made. They would make simple metal knives and use these for the reduction and carving of the *Nautilus* shell. Peter indicated that these tools were difficult to make and not high quality, making the working of *Nautilus* with these tools more difficult than it is today. Peter also told of a time when a woman visited his tribe from another area and taught them how to make better tools by heating iron. This improved the quality of the tools used, but they were still not as high quality as the tools used in the present day.

The early tools also included materials to abrade and polish the shell. For example, Peter described a leaf used for abrasion before sandpaper was readily accessible as well as the process to make this leaf suitable for the purpose of abrading shell:

> *"Like sandpaper for example, sandpaper, we have no sandpaper before, so we use a local leaf out from bush. We can go and cut the branch out of a tree then put it in the sun, and when the sun hits and makes it dry, we use the sandpaper. But today because, you know,*

Chinese and European bring all these from other countries, so we use this sandpaper now today, but before we just use a leaf out of a tree."

The progression of tools from hand-made or even collected from nature to the modern files, knives and saws used today is clear. When reflecting on when the transition from these earlier forms of tools into the tools used today, Peter defined World War II as a turning point for technology in the region. Prior to World War II, there was iron being used, but this was, as described above, mainly used to make basic tools for carving. WWII brought an influx of foreign people into the Solomon Islands. This region was a major part of the Pacific Theatre during WWII (Bullard 2007, p.30), and Peter explained that military involvement in the area not only saw a dramatic increase in the amount of new technology coming in, but it also created new avenues for selling craftwork and other goods to American troops.

While some of the technology used in the working of *Nautilus* has changed significantly in recent history, there are still aspects of the process that have remained relatively unchanged. Peter described the use of the '*Tita*' fruit for affixing *Nautilus* fragments in place during inlay work. Noting the fact that this fruit has been used for a very long time and continues to be used today, Peter explained that the resin (generated through crushing of this fruit) is waterproof and very adhesive. It has been used in the past to fix leaks in canoes, and was once the only substance used for adhering *Nautilus* shell into inlay work. Now Peter explains that modern glue and *Tita* fruit are used in conjunction, with the glue keeping the shell stuck to the wood and the *Tita* fruit being applied over the inlay area like a putty and sanded back until the whole surface is smooth. This process fills the spaces between the shell tablets themselves and any gaps between the shell tablets and the timber.

Moving beyond the practicality of working with *Nautilus* shells, Peter was also able to give detailed insight into the cultural significance of this shell and its importance in the wider community. One of the main sculptures carved by artisans in the Solomon Islands is the canoe prow ornament. This ornament is usually a highly decorated head, featuring intricate *Nautilus* shell inlay (see Figure 5.1). Peter described this figure, called '*Totoisu*', as being important for headhunting missions of the Western Province in the past, with this head figure affixed to the prow of the canoe to aid in a successful mission:

> *"…our ancestor before, they used this for headhunting, the spirit, very powerful. That's how they can won* [sic] *the battle when they go to war, because they use this as a devil, as a god."*

When asked about the current cultural significance of the carving and inlaying, Peter explained that the ornaments being created no longer hold the same spiritual importance that they held before the Solomon Islands were converted to Christianity. In the time of headhunting, the sculptures depicted gods that would aid in headhunting missions by searching for enemies and protecting the hunters. With the loss of headhunting as a traditional practice, the use of these god statues has lost its practical use. They still represent the strong cultural history of the Solomon Islands, but they are no longer used in the same respect. Many carvers from around the Solomon Islands no longer know the stories or traditions behind the sculptures they are carving. Peter described this as a terrible loss of tradition, as the artisans who do not know the stories and history of the pieces they are selling will often make up stories in order to sell their wares to tourists. This practice is causing false stories to become associated with very important spiritual icons, which is progressing the loss of this side of Solomon Island cultural identity even further.

In this sense, the goods are still incredibly important to the Solomon Island people, but now it is more of an economic importance than a solely spiritual one. These carvings and sculptures provide income for many families in the Solomon Islands and in Honiara in particular, as this is the hub of tourist activity in the nation. Peter explained this transition from cultural significance to economic significance:

> *"It's very interesting, very interesting. But not now, not today. Before. We never use this as a god today, it's finished. When the Christianity*

came, then all this is finished. But we can still make that for, to earn money you know, to get money, this day."

Another important economic aspect of the use of *Nautilus* shell is the initial acquisition of the shell. Peter stated that the *Nautilus* shell is so special because every part can be used to benefit someone. The samples that Peter works are usually collected on the beach after having washed up. Locals who know their value to carvers collect them and sell them to the carvers so they can be worked. This generates income for the finder of the shell, and ultimately for the carver as well, as they will go on to sell their shell inlay work at a profit. Peter explained that usually only the body whorl of the shell is used for generating inlay fragments, as it is thick enough to not break when worked. The shell further back, encasing the internal chambers, is harder to work with, and is usually left alone. In times of low supply, the less desirable parts of the shell can still be used for inlaying, but with a higher degree of difficulty. Alternatively, once the body whorl has been removed, the remainder of the shell (Figure 5.2) is often sold on to tourists. This was observed first hand on several occasions throughout the fieldwork trip to the Solomon Islands, with many market stalls seen to be selling specimens of *Nautilus* shell with the body whorl removed. Figure 5.2 shows a sample of this section of the shell from Peter's workshop, which was received as a gift from Peter.

Figure 5.2: Sample of *Nautilus pompilius* with the body whorl removed – from Peter Maepioh's workshop in Honiara, Solomon Islands.

Peter gave a demonstration of *Nautilus* shell working at his workshop outside his home in Honiara. This demonstration showed the process of *Nautilus* shell working from the initial reduction of the shell through to a finished product. Peter began with a whole *Nautilus* shell and, using a small sawblade, removed a section of the body whorl. With the body whorl removed, a smaller strip of the body whorl was then cut using the same saw. This strip was approximately 5-8 mm wide. At this point, Peter had a wooden carving that was to be inlaid with *Nautilus* shell on hand, and sized the strip of shell he had just cut with the recess carved into the timber to take the shell inlay. The strip of shell was found to be slightly too wide for the recess in the timber, so Peter proceeded to use a straight file to abrade the edge of the shell strip until it was a more suitable size (Figure 5.3).

Figure 5.3: Peter Maepioh using a file to abrade the edge of a strip of *Nautilus pompilius* shell.

Once the strip was resized to fit the recess in the carving, Peter used a knife to score-snap tablets of *Nautilus* shell measuring approximately 5-8 mm in length. This process of score-snapping was repeated consistently for each tablet generated and was the main technique utilised by Peter for creating tablets. Peter indicated that this technique was crucial for the working of *Nautilus* shell. These small tablets were then abraded into shape using a round file and a three-corner file. An example of a fragment worked using this technique can be seen in Figure 6.18.

Once all of the tablets were shaped, Peter smeared the recess in the carving with glue and placed the tablets end to end until the entire recess was filled (see Figure 3.1). This process would be followed by allowing the glue to dry before rubbing *Tita* fruit putty into the gaps along this inlaying. Once the *Tita* fruit putty had dried, the surface would be rubbed down with sandpaper to polish any rough residue off the inlaying.

This process shows the *Nautilus* shell from being a whole shell through to being a part of a completed inlaid sculpture. Peter's information was integral in the development of the methodology for the working of the *Nautilus belauensis* samples for comparison against the Golo Cave fragments and his input was greatly appreciated.

The second interview conducted was with Patricia George (Figure 5.4), the curator of the Solomon Islands National Museum shop. As the shop curator, Patricia has a vast knowledge of the different styles of working and inlaying from across the Solomon Islands. With her extensive knowledge in this field, Patricia was able to shed some insight into other uses for *Nautilus* and the origins of the various styles noted in the Solomon Islands today.

Figure 5.4: Patricia George inside the Solomon Islands National Museum shop, holding a *Nautilus* inlaid ceremonial weapon from Santa Catalina, Makira-Ulawa Province.

From discussing the main traditions of *Nautilus* shell inlaying with Peter Maepioh and Patricia George, it appeared that the bulk of *Nautilus* inlaying was based in the Western Province of the Solomon Islands. There are, however, a number of styles and traditions associated with a variety of regions around the Solomon Islands (Meyer 1995, pp. 398-405; Kjellgren 2007, pp. 168-171). When asked about the origins of different styles, Patricia described the various areas that also utilise *Nautilus* for inlaying and other forms of craftwork:

> *"…from my experience, more Nautilus shell is used in the Western Province and from some historical books that I have come through, like shell from Isabel they use Nautilus shell also. Central Islands yes they also use, like when I'm talking about Central is Florida Islands like Nggela, Savo, they do use Nautilus shell too. Also in Santa Catalina they also use Nautilus shell…"*

Patricia also explained that she believes a significant factor in the style depends on the individual artist. Based on their own personal preferences, artists may create certain tablet shapes and patterns, meaning that a number of different styles may appear even within the one region. This correlates with a statement Peter made in which he explained that the style of carving taught to him by his uncle is unique and he is the only one who does it in that specific way. In this sense, Patricia was able to point out a number of different pieces of *Nautilus* inlaid craftwork and provide details of the origins of these pieces.

For example, Figure 5.5 shows a canoe prow ornament in the typical style of the Western Province, while Figure 5.6 shows a *Nautilus* inlaid bowl from the Makira-Ulawa Province. The inlaying styles between these two pieces are significantly different. This can be explained through the difference in regional styles (as explained by Patricia George), but also by the difference in individual styles (as explained by Peter Maepioh). These styles represent specific cultural identities within the Solomon Islands, as different areas have their own practices and traditions when it comes to the art of inlaying, and different individuals within these areas have their own unique style. While this practice is mainly used for selling to tourists, the deep cultural significance of these pieces is evident in their use of spiritual motifs and god figures.

Figure 5.5: *Nautilus* inlaid canoe prow ornament from the Western Province.

Figure 5.6: Large *Nautilus* inlaid fish bowl from the Makira-Ulawa Province, Solomon Islands. Note the relatively crude shaping of the *Nautilus* shell tablets when compared to the tablets in Figure 5.5.

Some of the more contemporary carvings and inlay work show a higher degree of intricacy and detail, as modern and electrical tools are becoming much more widely used. Figure 5.7 shows another piece from the Solomon Islands National Museum shop. Patricia George drew attention to this piece and explained that it was a very detailed modern example of *Nautilus* shell inlay from the Western Province of the Solomon Islands.

Figure 5.7: *Nautilus* inlaid wooden mask from Western Province, Solomon Islands.

Patricia was also asked about other uses for *Nautilus* shell outside the scope of inlaying. She explained that *Nautilus* has a number of other artistic uses in the Solomon Islands:

> *"Yes actually Nautilus is used in every crafts* [sic] *in the Western Province, but could be in other parts also they used Nautilus shell but where actually it originated, no one knows."*

Patricia was also able to show a number of examples of *Nautilus* shell being used for purposes other than inlaying. One of the items shown was a decorative armband from the Santa Cruz Islands with several shaped shell fragments attached. This piece (Figure 5.8) contained a number of pieces of *Nautilus* shell that had been cut and shaped into elongate tablets, with the outer surface of the shell remaining in tact and visible – unlike the inlaid examples when the duller prismatic surface of the shell is hidden. These armbands once again display *Nautilus* in a highly decorative fashion, demonstrating its cultural significance. A description of similar body decorations using *Nautilus* is mentioned in Neich and Pereira (2004, p. 25).

Figure 5.8: *Nautilus* shell being used decoratively on an armband from the Santa Cruz Islands. Note the elongate tablets of *Nautilus pompilius* showing the nacreous and prismatic surfaces.

Patricia's help in identifying the various regions and styles of *Nautilus* shell working was invaluable for the progression of the ethnoarchaeological component of this study, and her assistance was greatly appreciated.

Chapter 6 – Dino-Lite Results

6.1 – INSTRON Dino-Lite Results

The *Nautilus* fragments generated through the INSTRON experiments were examined under low-powered microscopy and were found to contain several different edge types. These have been categorised as:

- Straight (all microstructural layers breaking concurrently and along the same path)
- Lamellar (breaking through the layers of the shell microstructure in a step-like fashion)
- Overhanging (wherein one microstructural layer was seen to significantly overhang beyond the general trend of breakage along the edge of the fragment)

The relative percentages of these edge types were visually estimated as a percentage of the total edge and are expressed in a table for each sample.

Nab-004 – Dorsal/ventral compression

INSTRON dorsal/ventral compression generated a small number of fragments from this whole shell sample of *Nautilus belauensis*. Of these fragments, four were selected as significant, with the remainder being too small to accurately analyse. These fragments primarily originated on the dorsal side of the shell, with fracture following two lobe-like patterns on either side of the central line of the shell. This sample was the only one of the three INSTRON-tested samples to experience failure posterior to the body whorl, thus exposing the chambers within the shell (likely due to the direct application of force to this area). This is generally not common as the shell is designed to fracture at the body whorl to protect the chambers of the posterior (Wani, 2004). This is due to the fact that catastrophic structural failure of these chambers will lead to a flooding of the shell and inevitable death of the organism. The edge types varied widely on the fragments generated through this compression. Straight (Figure 6.1), lamellar (Figure 6.2) and overhanging (Figure 6.3) edges were all observed. The estimated percentages of the edge types found on each fragment are listed in Table 6.1.

Figure 6.1: Straight edge on fragment Nab-004b (nacreous-side view) (40x).

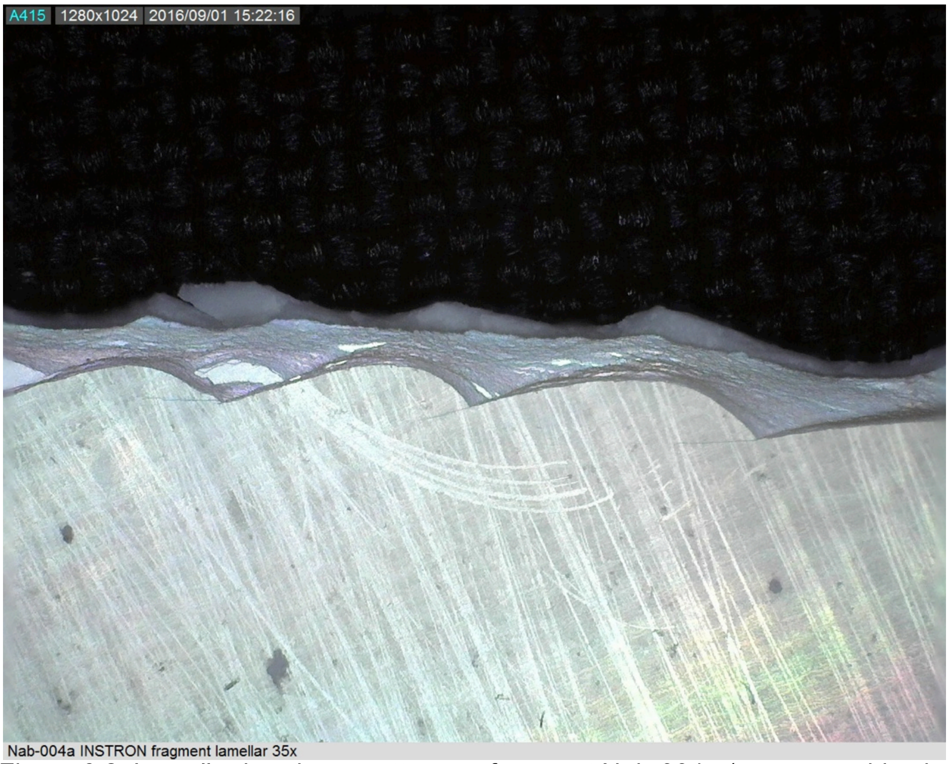

Figure 6.2: Lamellar breakage pattern on fragment Nab-004a (nacreous-side view). The uneven, wavy morphology of the nacre appears to follow the growth lines of the shell (40x).

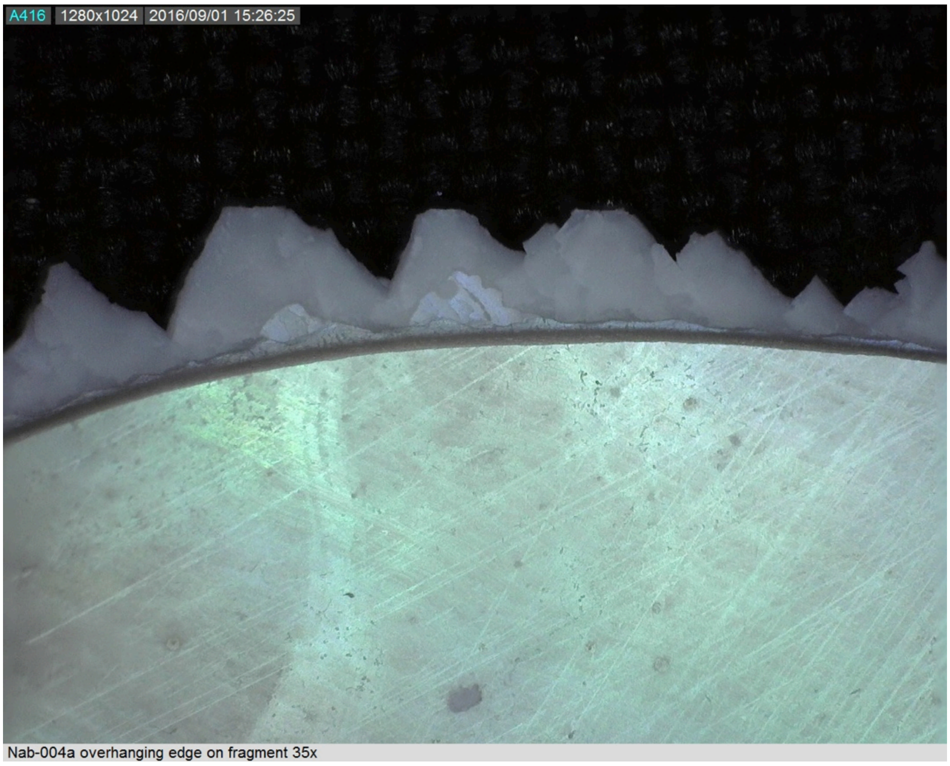

Figure 6.3: Overhanging edge on fragment Nab-004a (nacreous-side view) (35x).

Table 6.1: Percentage of edge types on fragments from sample Nab-004:

Sample:	**Straight (%):**	**Lamellar (%):**	**Overhanging (%):**
Nab-004a	60	25	15
Nab-004b	50	45	5
Nab-004c	80	15	5
Nab-004d	90	10	0

Nab-005 – Lateral compression

The INSTRON compression of Nab-005 in the lateral plane caused significant structural failure resulting in major cracking of the body whorl, but only generated a single, detached fragment. The chambers remained intact. Once again, this is a structural feature of the shell that enables the organism to survive predation and damage by directing fracture energy towards the body whorl of the shell, with the body whorl breaking most often and protecting the buoyancy chambers further back (Wani, 2004). This distribution of energy tends to cause a smaller number of large fragments to be generated, rather than a greater number of small fragments. Nab-005 seems to be a clear example of this, as dramatic structural failure caused cracking while only one fragment was generated (see Figure 6.4). The Nab-005a fragment was dislodged from the body whorl of the shell and exhibits mainly lamellar and straight breakage along its edge with one small region of overhang. Figures 6.5, 6.6 and 6.7 below demonstrate some of these edge types as generated through lateral compression, while Table 6.2 gives details about the edge type percentages.

Figure 6.4: Nab-005 – whole *Nautilus* shell on INSTRON stage after lateral compression test. Note the fragment missing from the body whorl of the shell (Nab-005a) at the contact point with the INSTRON stage and the crack running further into the body whorl.

Figure 6.5: Lamellar edge of laterally compressed Nab-005a fragment (nacreous-side view) (40x).

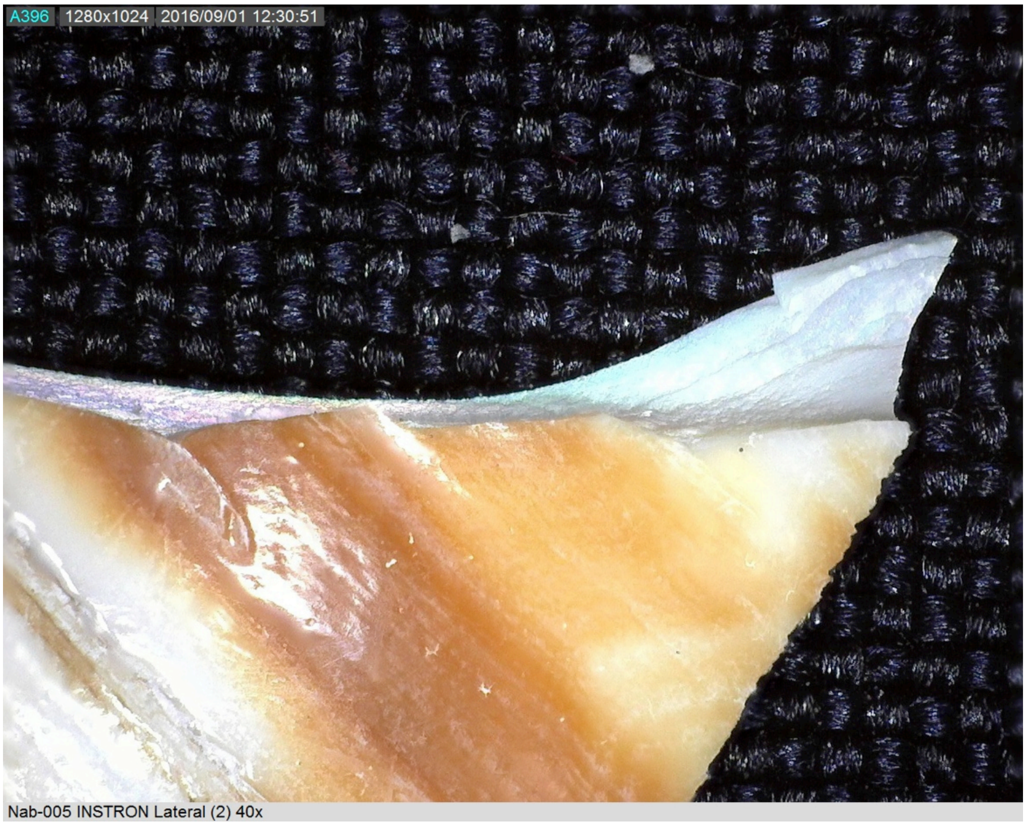

Figure 6.6: Overhanging edge on fragment Nab-005a (prismatic-side view) (40x).

Figure 6.7: Whole shell (Nab-005) showing where fragment Nab-005a was dislodged. Failure crack continues towards the bottom left of picture (45x).

Table 6.2: Percentage of edge types on fragment Nab-005a.

Sample:	**Straight (%):**	**Lamellar (%):**	**Overhanging (%):**
Nab-005a	35	60	5

Nab-019 – Anterior/posterior compression

The structural failure of sample Nab-019 in the INSTRON machine created five main fragments – one large and four smaller. As with Nab-005, the fracturing of this shell occurred in the body whorl, leaving the posterior section of the shell intact. The fracture of this shell was, unusually, at the thickest part of the shell – close to the umbilicus. During compression, the shell was seen to flex and deform before failure occurred, initially with a crack at the umbilicus and, as pressure mounted with continuing compression, the crack traversed the body whorl and terminated at the growing edge. The majority of the edges examined across these five fragments were found to be straight or lamellar, with very few exhibiting overhanging properties. Estimated edge type percentages are listed in Table 6.3, with Dino-Lite images of these edge types demonstrated in Figures 6.8, and 6.9.

Figure 6.8: Lamellar edge on fragment Nab-019 (prismatic side view) (45x).

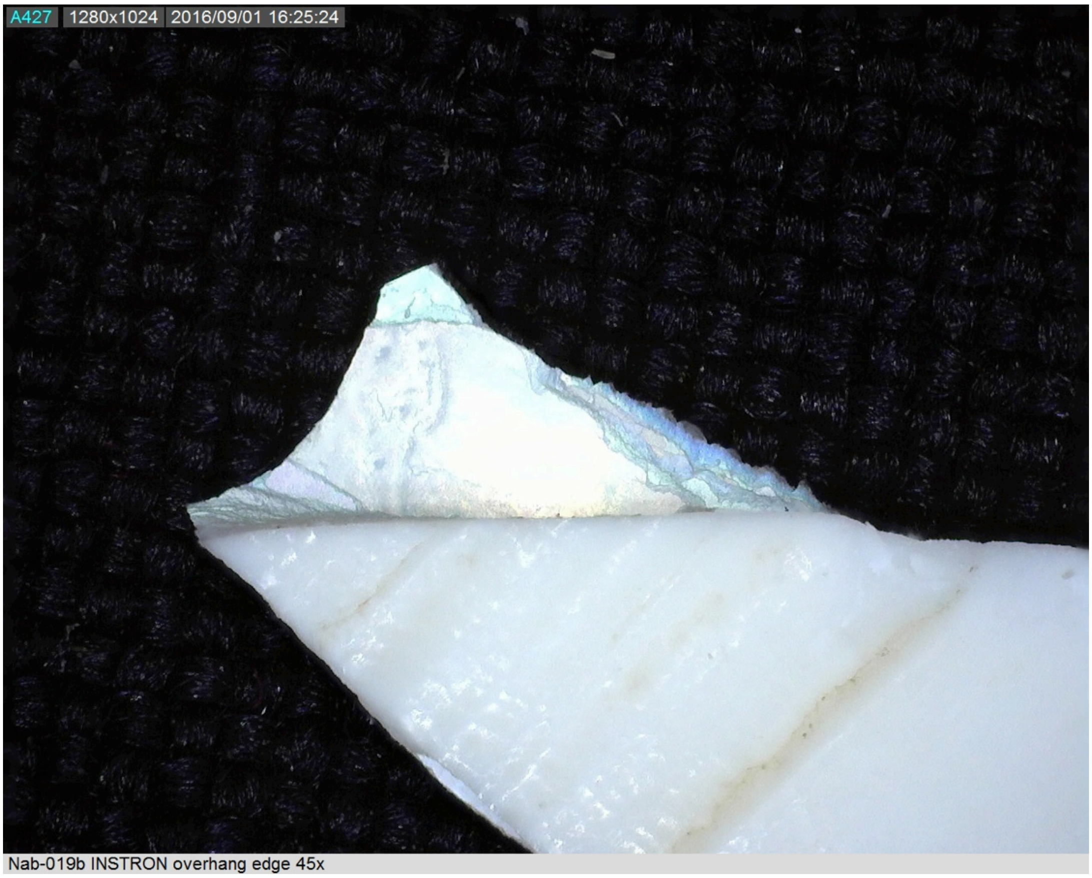

Figure 6.9: Overhanging edge on fragment Nab-019 (prismatic side view) (45x).

Table 6.3: Percentage of edge types on fragments from sample Nab-019.

Sample:	Straight (%):	Lamellar (%):	Overhanging (%):
Nab-019a	75	25	0
Nab-019b	45	50	5
Nab-019c	30	55	15
Nab-019d	60	35	5
Nab-019e	70	20	10

6.2 – Experimental working Dino-Lite results

The samples of *Nautilus* used for experimental working were examined under a low-power Dino-Lite microscope to observe the working traces left on the surface of the shell. This section presents the results and observations of this process for later comparison with samples of *Nautilus* recovered from Golo Cave. These experiments were conducted using a collection of different materials and varying numbers of gestures in order to create an extensive assemblage of worked fragments with which to compare the Golo Cave samples. Table 6.4 outlines the complete selection of experiments conducted in the experimental working phase of this project.

Table 6.4: Details of experimentally worked samples.

Exp. #:	Sample Used:	Technique:	Part of shell:	Material:	# of gestures:	Guide used?:
1	Nab-007g	Scoring	Body whorl	Basalt	50	Y
2	Nab-007f	Scoring	Body whorl	Basalt	100	Y
3	Nab-007j	Scoring	Body whorl	Chert	50	Y
4	Nab-007h	Scoring	Body whorl	Chert	100	Y
5	Nab-003	Scoring	Septal wall	Basalt	50	Y
6	Nab-003	Scoring	Septal wall	Basalt	100	Y
7	Nab-003	Scoring	Septal wall	Chert	50	Y
8	Nab-003	Scoring	Septal wall	Chert	100	Y
9	Nab-007k	Score-snap	Body whorl	Basalt	50	Y
10	Nab-001n	Score-snap	Body whorl	Basalt	100	Y
11	Nab-001m	Score-snap	Body whorl	Chert	50	Y

12a	Nab-001f	Score-snap	Body whorl	Chert	100	Y
12b	Nab-001g	Score-snap	Body whorl	Chert	100	Y
13	Nab-003	Score-snap	Septal wall	Basalt	50	Y
14	Nab-003	Score-snap	Septal wall	Basalt	100	Y
15	Nab-003	Score-snap	Septal wall	Chert	50	Y
16	Nab-003	Score-snap	Septal wall	Chert	100	Y
17	Nab-003	Abrasion	Body whorl	Basalt Abr. Block	20	N
18	Nab-003	Abrasion	Body whorl	Basalt Abr. Block	50	N
19	Nab-003	Abrasion	Body whorl	Basalt Abr. Block	100	N
20	Nab-003	Abrasion	Body whorl	Grind. block	20	N
21	Nab-003	Abrasion	Body whorl	Grind. block	50	N
22	Nab-003	Abrasion	Body whorl	Grind. block	100	N
23	Nab-003	Abrasion	Body whorl	Branching coral	20	N
24	Nab-003	Abrasion	Body whorl	Branching coral	50	N
25	Nab-003	Abrasion	Body whorl	Branching coral	100	N
26	Nab-003	Abrasion	Body whorl	Urchin spine	20	N
27	Nab-003	Abrasion	Body whorl	Urchin spine	50	N
28	Nab-003	Abrasion	Body whorl	Urchin spine	100	N
29	Nab-003	Abrasion	Septal wall	Basalt Abr. Block	20	N
30	Nab-003	Abrasion	Septal wall	Basalt Abr. Block	50	N
31	Nab-003	Abrasion	Septal wall	Basalt Abr. Block	100	N
32	Nab-003	Abrasion	Septal wall	Grind. block	20	N
33	Nab-003	Abrasion	Septal wall	Grind. block	50	N
34	Nab-003	Abrasion	Septal wall	Grind. block	100	N
35	Nab-003	Abrasion	Septal wall	Branching coral	20	N
36	Nab-003	Abrasion	Septal wall	Branching coral	50	N
37	Nab-003	Abrasion	Septal wall	Branching coral	100	N
38	Nab-003	Abrasion	Septal wall	Urchin spine	20	N
39	Nab-003	Abrasion	Septal wall	Urchin spine	50	N

40	Nab-003	Abrasion	Septal wall	Urchin spine	100	N
41	Nap-000	Scoring	Body whorl	Chert	100	Y
42	Nap-000	Score-snap	Body whorl	Chert	100	Y
43	Nap-000	Abrasion	Body whorl	Basalt Abr. Block	100	N
44	Nap-000	Abrasion	Body whorl	Grind. block	100	N
45	Nap-000	Scoring	Septal wall	Chert	100	Y
46	Nap-000	Score-snap	Septal wall	Chert	100	Y
47	Nap-000	Abrasion	Septal wall	Basalt Abr. Block	100	N
48	Nap-000	Abrasion	Septal wall	Grind. block	100	N
49	Nab-003	Abrasion	Body whorl	Ray Skin	20	N
50	Nab-003	Abrasion	Body whorl	Ray Skin	50	N
51	Nab-003	Abrasion	Body whorl	Ray Skin	100	N
52	Nab-003	Abrasion	Septal wall	Ray Skin	20	N
53	Nab-003	Abrasion	Septal wall	Ray Skin	50	N
54	Nab-003	Abrasion	Septal wall	Ray Skin	100	N

Scoring experiments

A number of score and score-snap experiments were conducted using *Nautilus* shell body and septal wall fragments. These experiments utilised both chert and basalt as scoring material and scored both body and septal wall fragments for 50 and 100 gestures each. These scores were guided by a palm mid-rib to ensure they followed a consistent trajectory.

Basalt flakes were used to score the *Nautilus* fragments on the nacreous side of the shell. These scores showed a relatively wide spread of splayed scores at the point of initiation (Figure 6.10). These scores generally converged into a finer track towards the point of termination, but were still relatively shallow. A significant amount of fine debris was generated throughout this procedure, with each score creating a small amount of fine powder.

The fragments scored with chert also displayed a minor degree of spread at the point of initiation of the score, but quickly converged into a more concentrated score line with greater depth and consistency than that of the basalt scores (Figure 6.11). These scores created more debris than the basalt scores and the narrower track of score line ran deeper into the shell microstructure.

Another set of experiments was conducted using the same score materials and gesture numbers, however, shells were also snapped along the score line. It was noted through these experiments that the samples scored by basalt and chert both snapped with relative ease, with the main difference between these two materials being that the snap of the chert-scored example was more predictable and controlled due to the narrower spread of the score lines. The basalt samples snapped easily, but with less certainty over the exact trajectory of the breakage due to the broader spread of score lines. The samples that had been snapped all exhibited some degree of edge rounding, as the scoring wore down into the microstructure of the nacreous surface prior to snapping.

Figure 6.10: nab-007f – *Nautilus* fragment scored by basalt for 100 gestures. Note the broad spread of the scores relative to Figure 6.11 below (50x).

Figure 6.11: Nab-007h – *Nautilus* fragment scored by chert for 100 gestures. This sample has a very narrow spread of scores (50x).

Score and score-snap experiments were also conducted on septal wall fragments of *Nautilus* shell using the same materials and gestures as those listed above. These experiments were found to have very similar results to the body whorl fragments, with the exception that the score lines tended to be shallower than the body whorl fragments. The septal wall exhibits a nacreous microstructure that does not exhibit layering (Dauphin 2006) and, as such, similar results to the working of the nacreous layer of the body whorl fragments were expected. An example of a septal wall worked fragment can be seen in Appendix 3.

Abrasion experiments

Abrasion experiments were also conducted on *Nautilus* shell fragments to compare against the Golo Cave fragments. These experiments involved using five different materials (all hypothetically available to the prehistoric inhabitants of Golo Cave) to abrade the edge of a number of *Nautilus* shell fragments with 20, 50 and 100 gestures. The materials chosen for these experiments were vesicular basalt abrasion blocks, a vesicular basalt grinding block, branching coral (*Acropora* sp.), sea urchin spines (*Heterocentrotus mamillatus*), and dried ray skin (*Aptychotrema rostrata*). The abrasion for each of these materials was conducted on the prismatic surface of the *Nautilus* shell fragment at a 45-degree angle to the edge of the fragment.

The first abrasion experiments used vesicular basalt abrasion blocks to work the edge of the shell fragment. This technique was noted to be highly effective, with a significant amount of debris generated through the working of the fragment (Figure 6.12). After examining a 100-gesture fragment under Dino-Lite low-powered microscopy, it was noted to have very obvious and notable traces of edge working. The sample had a very clear distinction between the unworked surface of the shell and the well-rounded worked edge. Small traces of basalt were also noted on the edge of the shell fragment.

Figure 6.12: Nab-003 exp#19 – *Nautilus* body whorl fragment worked by basalt abrasion block for 100 gestures (note abrasion along the edge) (50x).

The next experiments conducted were on the basaltic grinding block. These experiments involved working the shells against the grinding block at a 90-degree angle and abrading the flat edge of the fragment against the grinding block. This experiment generated a unique working pattern that involved mainly the flat edge of the shell rather than the edge of the surface. During the 100-gesture experiment, a significant amount of debris was generated and left on the surface of the grinding block. Upon low-powered microscopic analysis of this sample (Figure 6.13), significant striations were observed along the worked edge of the fragment. The edge had also experienced rounding onto the nacreous and prismatic surfaces of the fragment. This was most likely due to slight angularity of the gesture as keeping the shell at an exact 90-degree angle was nearly impossible.

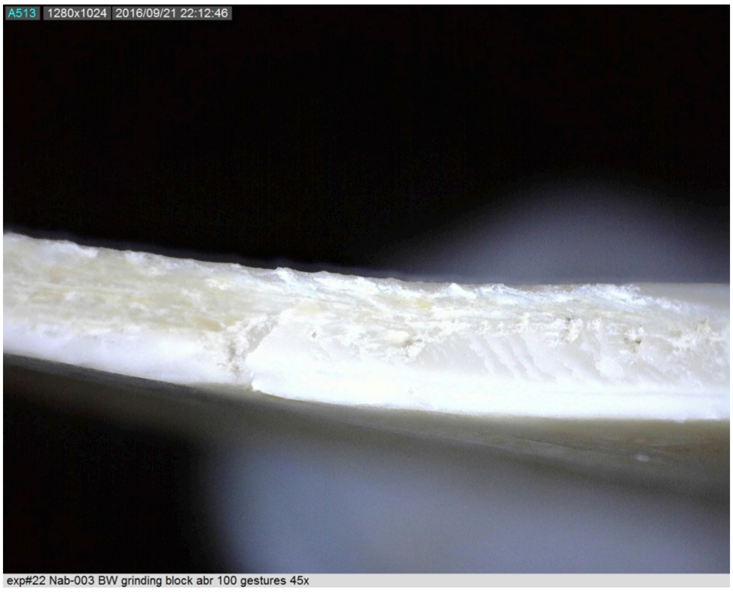

Figure 6.13: Nab-003 exp#22 – edge of *Nautilus* body whorl fragment after abrasion on basalt grinding block for 100 gestures (45x)

Septal wall fragments were also subjected to this style of abrasion. It was noted that the septal wall fragments appeared slightly more resistant to abrasion – most likely due to the homogenous nacreous microstructure of septal wall when compared to the body whorl fragments, which exhibit a three-layered spherulitic prismatic, prismatic and nacreous structure. The samples of grinding block-abraded *Nautilus* shell also exhibited striations along the edge of the worked surface (Figure 6.14) and left traces of debris on the abrasion block as they were worked.

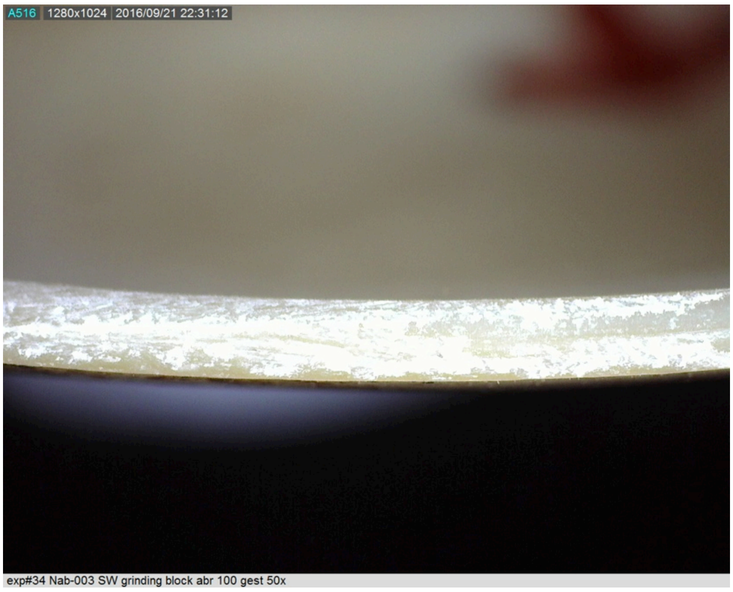

Figure 6.14: Nab-003 exp#34 – septal wall fragment abraded with basalt grinding block for 100 gestures (50x).

Terminal branches of branching coral (*Acropora* sp.) were also used to work *Nautilus* shell fragments. The 45-degree angle abrasion along the edge of the fragment generated similar wear patterns to the basalt abrasion blocks, but with slightly less attrition noted. The reason for this apparent decrease in degree of abrasion may be that the *Nautilus* fragment appeared to wear down the *Acropora* sp. more than it wore the basalt abrasion blocks. In this sense, while the *Nautilus* fragment was being worked, the branch coral was also experiencing significant abrasion against the edge of the *Nautilus* shell.

Figure 6.15 shows a body whorl fragment of *Nautilus* that has been abraded by the *Acropora* sp. for 100 gestures. A distinct line of white, powdery debris can be seen to mark the edge of the abraded surface against the non-abraded surface. Figure 6.16 shows a septal wall fragment that has been abraded by *Acropora* sp. for 100 gestures. This fragment also shows a clear distinction between the worked and unworked section of the shell. Striations can also be noted along the worked surface of the septal wall fragment. As an abrasive material, *Acropora* sp. is relatively effective, with significant edge rounding of samples noted. It generated a large amount of shell debris during working, but also became worn throughout this process.

Figure 6.15: Nab-003 exp#25 body whorl fragment after abrasion by *Acropora sp*. for 100 gestures (50x).

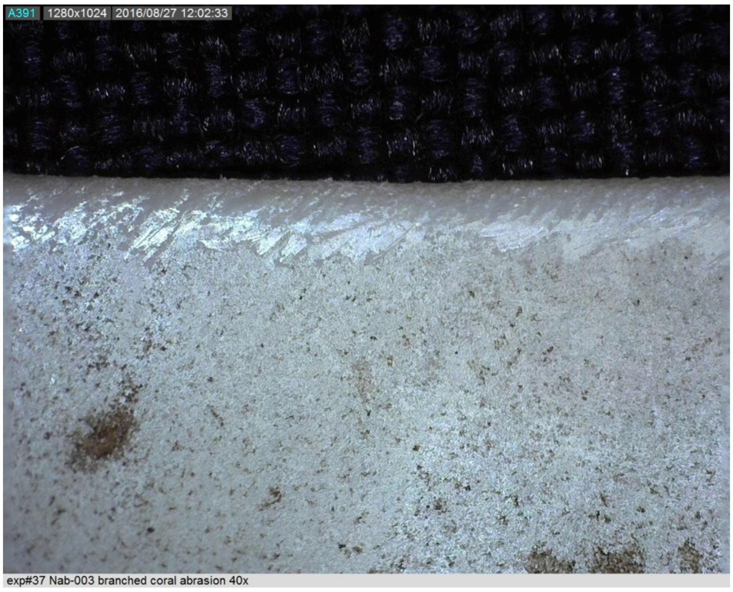

Figure 6.16: Nab-003 exp#37 – septal wall fragment after abrasion with *Acropora* sp. for 100 gestures, (40x).

Sea urchin spines (*Heterocentrotus mamillatus*) were also used to work the edges of *Nautilus* shell fragments. When compared to previous techniques, the urchin spines had relatively poor abrasive qualities and functioned more as polish than an abrasive. Very little debris was generated throughout the working process. On the 100-gesture sample, the apparent line between the worked and unworked surface of the shell was far less distinguishable when compared to the previous examples (Figure 6.17). The edge appears as slightly rounded, with a small amount of *Heterocentrotus mammillatus* spine residue left on the edge of the fragment. Once working was completed, the spine itself had a small amount of wear on the outer surface.

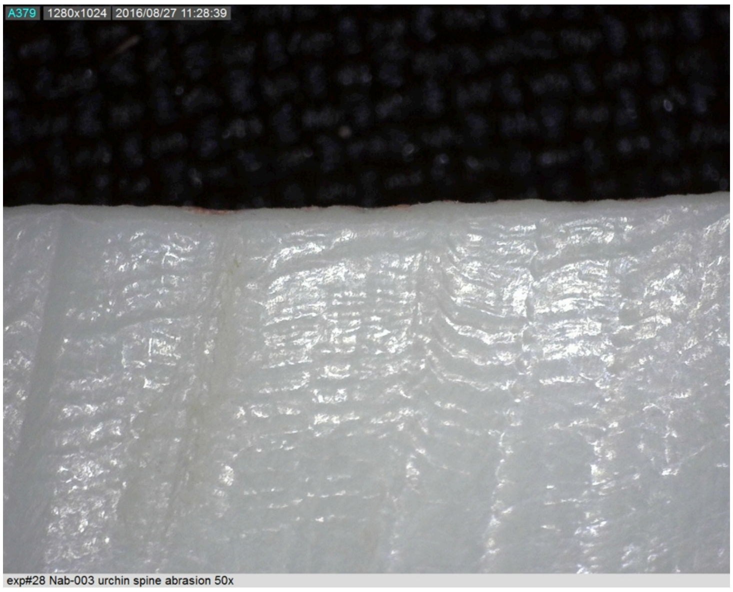

Figure 6.17: Nab-003 exp#28 – *Nautilus* body whorl fragment after abrasion by *Heterocentrotus mammillatus* spines for 100 gestures. Note the lack of a distinct line of working as seen previous examples, with only minor edge rounding and polish seen (50x).

The final material used for the abrasion experiments was dried ray skin (*Aptychotrema rostrata*). This material generated results very similar to that of the *Heterocentrotus mammillatus* spine experiment. A relatively small degree of abrasion was noted, with a very small amount of debris being generated during the experiment. The ray skin was being abraded to a higher degree than the shell during the working process. Low-powered microscopy of the 100-gesture sample also revealed a primarily polished edge with only a small amount of abrasion and rounding. This stands in contrast to the abrasion materials such as the lithic blocks and *Acropora* sp. branching coral that had a much more profound abrasive effect on the *Nautilus* shell.

Worked offcut from Peter Maepioh

A sample of *Nautilus pompilius* collected in the Solomon Islands from Peter Maepioh's workshop was also examined under Dino-Lite microscopy. Sample SI-003 (Figure 6.18) was examined to determine traces left by modern tools.

This sample was worked using a steel knife to score-snap the piece away from a larger section of shell, then abraded with a round metal file and a three-corner metal file to shape the piece for the purpose of inlaying into carved wood. The nacreous surface of the shell was scored with a blade and then snapped, generating a clear and distinct break throughout the different microstructural layers. The other worked edges show a very smoothed appearance, with apparent striations on some surfaces indicating the working traces of the file. Some debris is also evident on the surface of the worked areas, with the metal files causing very prominent and well-defined abrasion. As an abrasive material, the metal tools far exceeded the abrasive qualities of any of the naturally-available materials tested.

Figure 6.18: SI-003 – sample of *Nautilus pompilius* from Peter Maepioh in the Solomon Islands. This sample has been worked with a knife and two metal files (50x).

As a matter of course, experiments 41-48 tested samples of *Nautilus pompilius* to compare against worked samples of *Nautilus belauensis* to establish that the two species were analogous for the purposes of this study. These experiments found the working on the *N. belauensis* to be no different to the working traces on *N. pompilius*. This result was expected, as the microstructure of both species is identical and the two have been described as sibling species (Saunders & Landman 2009, p. xli). An example of worked *N. pompilius* can be seen in Appendix 4.

6.3 – Golo Cave Dino-Lite results

The Golo Cave fragments (as pictured in Chapter 4.4) were examined under low-powered Dino-Lite microscopy to inspect for any subtle traces of working that may not have been visible without microscopy, or to examine more closely the apparent traces of working that were visible without microscopic analysis. This procedure enabled the selection of which Golo Cave fragments were to be inspected using high-powered SEM microscopy, as samples were identified as potentially worked or needing further analysis. Through Dino-Lite examination of the Golo Cave samples, a number of fragments were found to have characteristics indicative of working.

Sample GC-001, a *Nautilus* body whorl fragment, was found to have edge morphologies that varied widely around the perimeter, with some straight, lamellar and overhanging edges noted. The straight edge of this sample was examined and shows possible signs of abrasion (Figure 6.19). There is a notable rounding to this edge, however, it does not seem to be uniformly or evenly abraded, meaning this may be a result of taphonomic processes rather than pre-depositional working. The lamellar and overhanging edges do not appear to contain any notable features or characteristics that would indicate a worked sample. This sample was selected for further SEM analysis to determine if edge rounding was caused by abrasion.

Figure 6.19: GC-001 – *Nautilus* fragment with possible abrasion traces (40x).

Sample GC-002 (Figure 6.20) showed visible signs of working without the aid of microscopy. Under Dino-Lite microscopy, these traces were far more prominent. A number of score lines can be seen on the nacreous surface of this fragment. Trending in approximately the same direction, these scores occur parallel to the edge of the fragment, likely indicating a score-snap edge. The edge itself appears to be straight with edge rounding noted along its length. This would likely be a result of the score gouging into the nacreous surface of the shell before snapping. A number of scores can be seen, indicating a repeated concerted effort to score this fragment in the desired direction – most likely for the purpose of generating a line of weakness to control a snap (score-snap).

Figure 6.20: GC-002 – apparent score marks on the nacreous surface of the fragment alongside an edge exhibiting rounding (40x).

No other fragment exhibited such obvious traces of working as found on GC-002, however, there were a number of other fragments that showed signs of possible working that required further examination under SEM. GC-004 was seen to have a straight edge with possible rounding, (similar to that noted on the edge of fragment GC-002). This pattern may be characteristic of some form of abrasion or score-snap surface (Szabó & Koppel 2015). GC-004 also exhibited marks on the nacreous surface that were noted as areas of interest to be examined under SEM.

Sample GC-005 is a body whorl fragment that appeared to show potential indications of abrasion, with straight edges displaying traces of rounding. Some straight edges of this fragment appeared to have similar characteristics to sample GC-002, which may be the result of a score-snap process or edge abrasion. For these reasons, GC-005 was selected as a sample that should be examined more closely using SEM imaging.

GC-007 was also identified as a fragment of interest. It showed straight edge patterns similar to those generated through the experiments in Chapter 4.3 and those seen on the edge of fragment GC-002. Portions of the straight edge appeared to have been rounded in a consistent and uniform manner, making GC-007 a high priority sample for SEM analysis. GC-007 also exhibited some pitting on the nacreous surface that does not appear to be consistent with any known taphonomic process (Figure 6.21). These pitting structures appeared to have some form of residue in the bottom, thus further SEM analysis was required to investigate this anomaly further.

Figure 6.21: GC-007 – pitting noted on nacreous surface of archaeological *Nautilus* fragment (40x).

Sample GC-009, a septal wall fragment, was noted to contain a high percentage of straight edges (around 95% - see Table 4.2). This high percentage of clear, straight edges was a key reason for this fragment being selected for further SEM analysis. The sample also showed a small number of unusual edge morphologies, with an apparent notch noted along one edge. This was noted as an area of interest for further SEM inspection.

The final fragment selected for SEM analysis was GC-012. This sample is a septal wall fragment that has undergone significant burning and delamination. It is the oldest fragment out of the twelve Golo Cave samples with an associated ^{14}C age of 28,740 ± 474 BP (Szabó & Koppel 2015). Upon inspection under Dino-Lite microscopy, this sample appeared to show little solid evidence of working traces. It did exhibit a relatively high straight edge percentage with 80% of the edge surfaces being straight. This may be an indicator of score-snapping or working into a specific shape, however, with such severe damage to the shell fragment, identification of working traces may be impossible.

A number of Golo Cave samples examined under Dino-Lite microscopy were found to not contain major points of interest and were deemed unlikely to have been experimentally worked based on their edge morphology and surface condition. GC-003 was found to have significant delamination on a number of surfaces, making identification of edge wear on any original surfaces impossible. This was a problem also found on samples GC-010 and GC-011. With these fragments in poor condition, delamination had caused most of the original edges to degrade away, leaving underlying layers revealed. While this may have been an interesting point of note for the degradation of *Nautilus* over time, it did not serve the aims of this project, thus these samples were left with no further avenues of examination covered by the scope of this project.

Fragment GC-006 was not in poor condition as with the above samples. Rather, this sample lacked any notable evidence of being a potentially worked fragment. The edges of GC-006 showed both straight and lamellar morphologies, with neither edge type showing any trace of striations or rounding. Furthermore, the nacreous and prismatic surfaces of this fragment were not found to contain scores or any other anomaly that required further examination under high powered SEM microscopy.

The Dino-Lite results of the INSTRON, experimentally worked and Golo Cave fragments of *Nautilus* have given a clearer picture of the edge morphologies generated through breakage and working of shell fragments and their manifestation on archaeological fragments. The next phase of examination, the SEM analysis, will give a closer and more detailed look at these fragments and provide more precise evidence with which to link their origins.

Chapter 7 – SEM results

7.1 – INSTRON SEM results

The Dino-Lite analysis of the INSTRON fragments gave the clear indication that there are three main types of breakage pattern in a fragment of *Nautilus* that has undergone compressional stress. These were: straight, lamellar and overhanging. As SEM analysis of these fracture patterns was required, Dino-Lite images were inspected to find samples that demonstrated these patterns most clearly. Fragment Nab-004a was found to contain each of these fracture patterns on its edges, and was hence selected for further SEM analysis. The microscopy was conducted at the University of Wollongong Innovation Campus using a JEOL JSM-649OLA scanning electron microscope.

Fragment Nab-004a was generated through dorsal/ventral compression in the INSTRON machine (as noted in Chapter 4.1) and originated from the body whorl of the shell. The fragment exhibits a straight fractured edge in which all of the microstructural layers have broken along the same line (Figure 7.1). This edge type appeared to be the most common out of the INSTRON samples examined (see Tables 6.1, 6.2 and 6.3). As seen in Figure 7.1, straight breakage along the edge of the fragment can be very clean and sharp. This would suggest that sharp, uniform lines are not necessarily indicative of shell working when comparing to the Golo Cave fragments later.

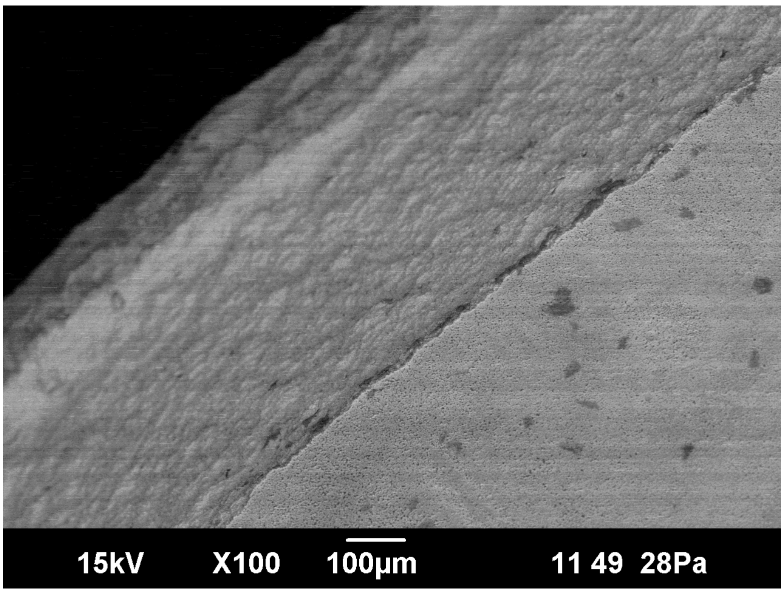

Figure 7.1: Nab-004a straight edge SEM image (15kV, 28Pa).

Nab-004a also exhibited a lamellar fracture pattern. This pattern involves the differential breakage of the microstructural layers of the *Nautilus* shell, resulting in a step-like edge appearance. This edge type was the second most commonly found on the INSTRON samples (see Tables 6.1, 6.2 and 6.3). An example of this edge type can be found in the Appendix 5.

Overhanging edges were also observed on fragment Nab-004a (Figure 7.2). Being the least common edge type found on the INSTRON samples, overhanging edges were found to make up an average of only 6.5% of all INSTRON sample edges. These overhanging edges were usually observed as small protrusions of the nacreous layer far beyond the point of breakage for the prismatic layer of the shell (as seen in Figures 6.3 and 6.9). These edges were generally also observed to be very angular and sharp, with no edge rounding present.

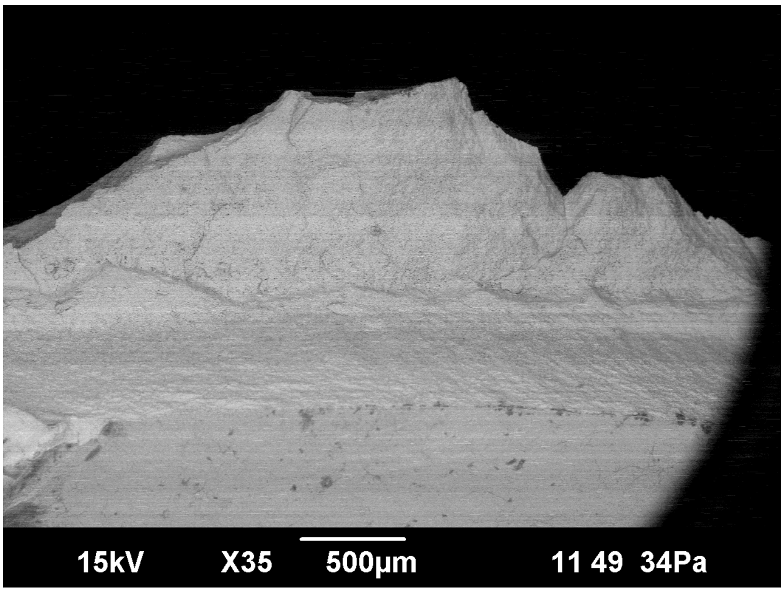

Figure 7.2: Nab-004a fragment with overhanging edge (15kV, 34Pa).

Nab-004a also exhibited an unusual curved breakage edge (as seen in Figure 6.2). Appearing to follow the growth lines of the shell, this pattern was examined under SEM microscopy (Appendix 6). It exhibits sharp edge lines but also appears to show some differential breakage between the microstructural layers of the shell.

7.2 – Experimental working SEM results

The experimental phase of this project involved taking a number of materials that would have been available to the occupants of Gebe Island in prehistory and using them to work *Nautilus* shell fragments using techniques and practices observed during field work in the Solomon Islands. This process yielded a large number of worked samples, which were then examined under low-powered Dino-Lite microscopy. Following this process, a number of worked samples were then selected for further analysis under high-powered SEM microscopy. These samples were selected based on their diversity, quality and high degree of notable working traces. The following outlines the results of the SEM analysis of seven experimentally worked body whorl fragments of *N. belauensis* and the working traces observed though this microscopic analysis. The microscopy was conducted at the University of Wollongong Innovation Campus using a JEOL JSM-649OLA scanning electron microscope. All samples were uncoated and imaged using low-voltage and low-pressure conditions.

The score-snap experimental samples chosen for SEM analysis involved 1) scoring a body whorl fragment with basalt for 100 gestures (Figure 7.3) and 2) scoring a body whorl fragment with chert for 100 gestures (Figure. 7.4). These two techniques showed varying traces, with basalt producing a generally broader area of scoring with shallower scores. The chert scores were better defined and deeper, with a narrower area of spread. This was due to the fact that the gestures with chert were able to follow the score line from the previous gesture more easily than the basalt fragment.

Each of these two techniques produced a relatively sharp snap with only minor edge rounding noted in Figures 7.3 and 7.4. This edge fracture shows a clean break across all microstructural layers of the *Nautilus* fragment worked with this technique. Also important to note was the significant amount of debris generation in the score lines, particularly evident with the chert score snap experiment. An example of this debris generation can be seen in Appendix 7.

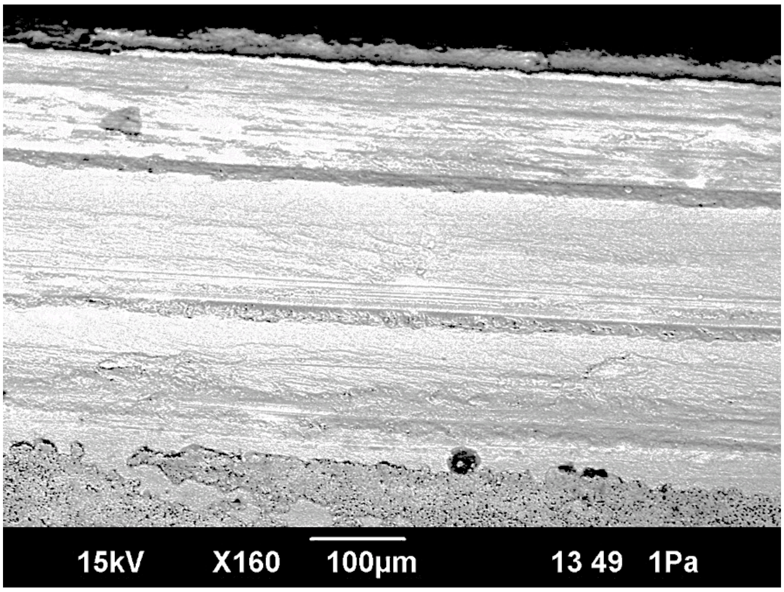

Figure 7.3: Nab-001n – body whorl fragment score-snapped using basalt for 100 gestures (15kV, 1Pa).

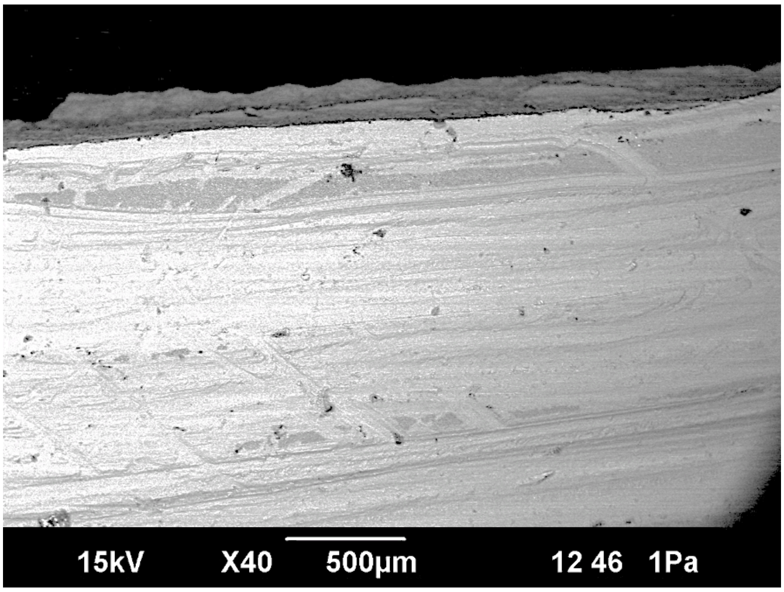

Figure 7.4: Nab-001g – body whorl fragment score-snapped using chert for 100 gestures (15kV, 1Pa).

Five samples were chosen for SEM analysis from the abrasion experiments. These experiments were conducted using five different abrasive materials, each with 100 gestures. The five materials used were vesicular basalt abrasion blocks, a basalt grinding block, branching coral (*Acropora* sp.), sea urchin spines (*Heterocentrotus mammillatus*), and ray skin (*Aptychotrema rostrata*). These materials were selected due to their availability to inhabitants of Gebe Island in prehistory, as well as through the discussion of early tools used for *Nautilus* working with Peter Maepioh from the Solomon Islands fieldwork component of this study.

Sample Nab-003 (exp#19) was worked using vesicular basalt abrasion blocks for 100 gestures on the prismatic-side edge of the shell fragment (with gestures conducted at around a 45-degree angle to the edge of the fragment). It was noted to have significant rounding, with striations visible along the shell surface following the trend of the gesture direction. Szabó and Koppel (2015) noted edge rounding on archaeological samples of *S. flexuosa* shells also recovered from Golo Cave. The edge appears to be relatively regular with consistent rounding and wear. When compared to the INSTRON samples under SEM (as seen in section 7.1), there is a notable difference in edge morphology, with this worked sample showing very clear working traces along the edge. This material was highly effective at abrading the *Nautilus* shell edge and, during the course of the experiment, a relatively large amount of powder debris was generated from the shell itself.

Sample Nab-003 (exp#22) was worked using a basalt grinding block. The edge of this sample had been worked by making contact with the grinding block at a 90-degree angle and conducting gestures in a pulling motion across the surface of the block (as seen in Figure 4.12). SEM analysis of this sample showed clear striations along the worked edge surface in the general trend of the gesture direction. The edge that was in direct contact with the grinding block showed significant working traces, while the prismatic surface of the fragment showed only minor edge rounding. This would have likely been caused by slight angularity of the gestures on the grinding block, with subtle angle changes causing a small amount of the prismatic surface to also become rounded. This material was highly effective for abrasion of the shell and powdery traces of shell debris were left along the surface of the block with each gesture completed.

Sample Nab-003 (exp#25) was abraded using branching coral (*Acropora* sp.). Once again, significant edge rounding was noted in this sample (Figure 7.5), with a relatively consistent surface generated though this working. This sample lacked the striations observed on samples Nab-003 (exp#19) and Nab-003 (exp#22). This was likely a result of the softer nature of the branching coral relative to the basalt used to abrade these earlier samples. Concurrently, very little debris was generated from the *Nautilus* shell in this experiment. Instead, the branch coral itself was also abraded and produced a fine, white powder of debris. After completion of the experiment, the stem of the branch coral was observed as worn down through the gestures performed. This material achieved a more mild degree of abrasion than the basalt materials used, however, definite abrasion and edge rounding were still observed.

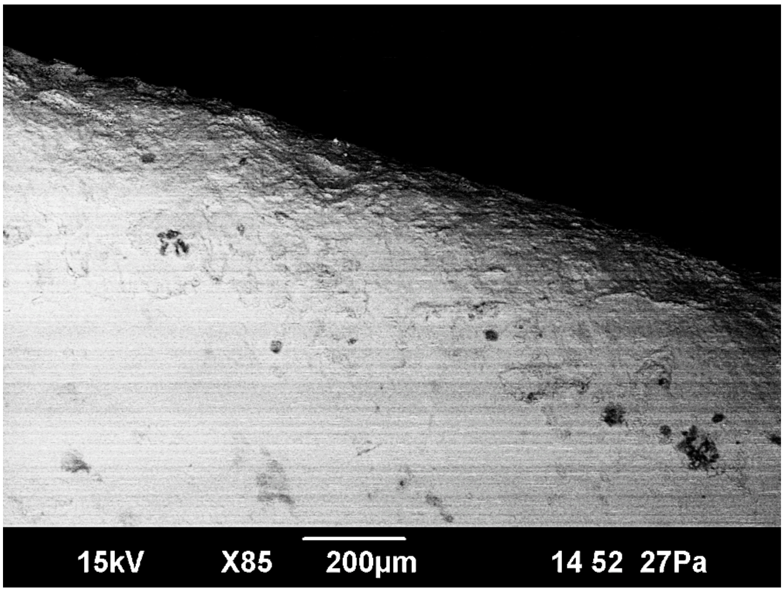

Figure 7.5: Nab-003 (exp#25) fragment exhibiting edge rounding after abrasion with branch coral (*Acropora* sp.) for 100 gestures (15kV, 27Pa).

Sample Nab-003 (exp#28) was abraded using sea urchin spines (*Heterocentrotus mammillatus*) (see Figure 4.14). This method of abrasion caused minor edge rounding of the sample with a clear line between the unworked prismatic layer of the shell and the worked prismatic layer closer to the edge of the sample (Figure 7.6). This sample exhibits a more polished appearance than the samples worked by other materials, which can be attributed to its finer-grained structure. This sample was also found to have very little debris generation, with small amounts of the *Heterocentrotus* *mammillatus* spine becoming dislodged from the spine during the experimental process. After the experiment had been completed, the spine was found to have a small amount of wear due to contact with the *Nautilus* shell fragment. These spines were found to be a relatively poor material for abrasion, with very little wearing down of the *Nautilus* shell fragment. It was more effective in a polishing capacity.

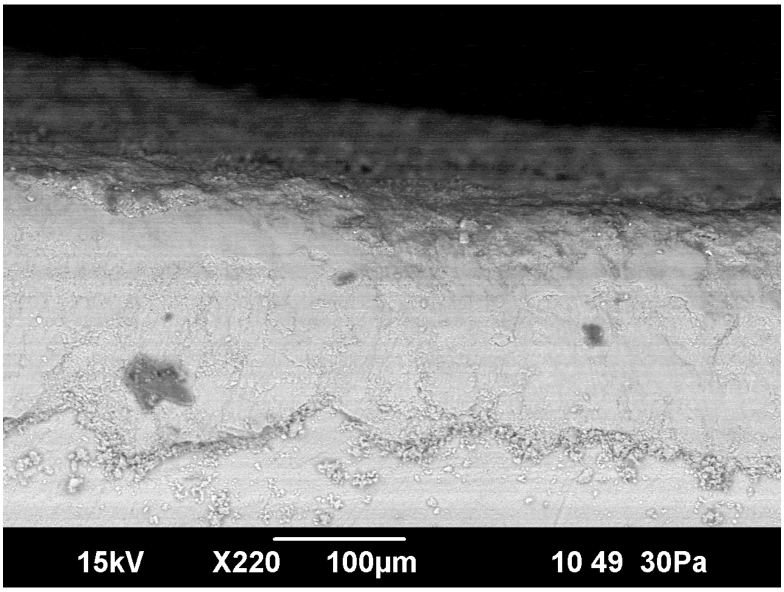

Figure 7.6: Nab-003 (exp#28) – edge rounding and polishing after abrasion with sea urchin spine (*Heterocentrotus mammillatus*) for 100 gestures (15kV, 30Pa).

The final experimentally worked sample examined under SEM was Nab-003 (exp#51). This sample had undergone 100 gestures of abrasion with ray skin (*Aptychotrema rostrata*). This abrasion caused minor edge rounding (Appendix 8), but seemed to produce a more notable polish on the edge of the sample rather than heavy abrasion. During the experimental process, little to no debris generation was noted on the *Nautilus* sample; however, the ray skin being used to abrade the shell was worn down and damaged during this process. In essence, this sample shares more similarity with Nab-003 (exp#28) abraded with urchin spine. The polishing effect is very similar and the samples exhibit roughly the same degree of edge rounding. As an abrasive material, the ray skin was relatively poor, with only minor abrasion noted. This material was more suited to polishing the sample rather than causing heavy abrasion.

Also examined under SEM was a worked sample of *Nautilus pompilius*, collected from Peter Maepioh as offcuts from his workshop in Honiara, Solomon Islands. Sample SI-003 (Figure 7.7) was worked using a knife, a round file and a straight file in order to cut and shape it into a tablet for inlaying. This sample gave a clear indication of the traces left by modern tools on *Nautilus* shell. The file-abraded edges show a uniform smoothness, with notable edge rounding on the surface of the shell. Closer SEM analysis of the file-abraded edges showed very fine striations caused by the file along the length of the abraded surface, showing a general uniformity. Striations can also be seen on the shell surface in Figure 7.7 as a result of polishing the sample with a rough abrasive (likely a wire brush or sandpaper). One edge of sample SI-003 was score-snapped using a steel knife. This edge shows score traces from the blade and also exhibits significant edge rounding. Observing the use of these modern tools by Peter Maepioh in his workshop clearly showed the relative ease of using modern tools compared to tools that would have been used in prehistory. The metal files and knife were very effective at scoring and abrading this material into the desired shape with far less time and effort required than when using lithic or organic materials to abrade the *Nautilus* shell.

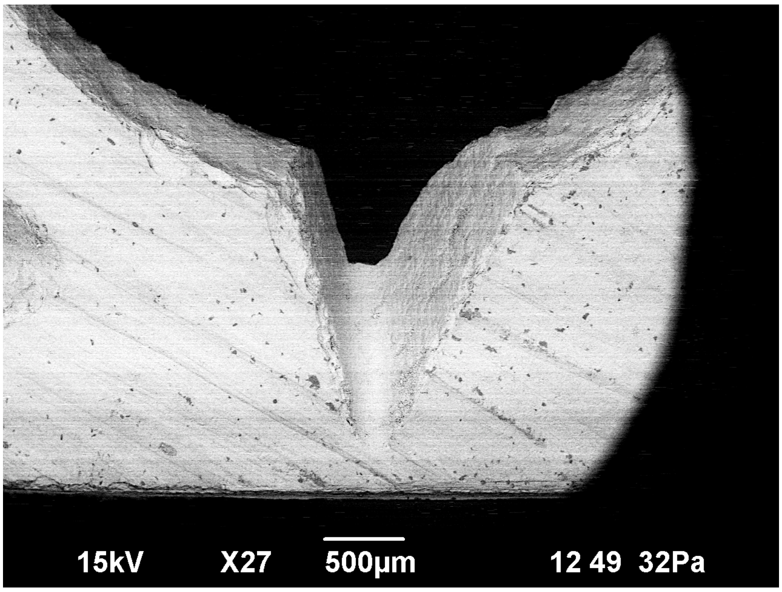

Figure 7.7: SI-003 – score-snap and abraded fragment of *N. pompilius* worked by Peter Maepioh in Honiara, 2016 (15kV, 32Pa).

7.3 – Golo Cave SEM results

Scanning electron microscopy was conducted on a selection of the fragments recovered from Golo Cave in order to identify any possible traces for working as established in the experimental working phase of this project. The microscopy was conducted at the University of Wollongong Innovation Campus using a JEOL JSM-649OLA scanning electron microscope. Due to the archaeological nature of the fragments, coating prior to SEM analysis was not an option, as it would alter the culturally and historically significant samples. As such, all samples were imaged uncoated, using a combination of low voltage and low-pressure conditions.

One of the major characteristics observed in number of the Golo Cave fragments under SEM analysis was the presence of acid dissolution. Sample GC-001 (Figure 7.8) shows a small amount of acid dissolution (identified through the layered exposure of the microstructure and the poor condition of the shell surface). This makes identification of any working traces in these zones impossible. Also visible on this sample are a number of darker patches, which may be adhering residue – possibly plant. This residue may be the reason for the acid dissolution noted on this sample, as contact with plant matter is a common cause of acid dissolution (Kotzian & Simoes 2006). This residue appears to be applied and may be an indicator of a modified sample.

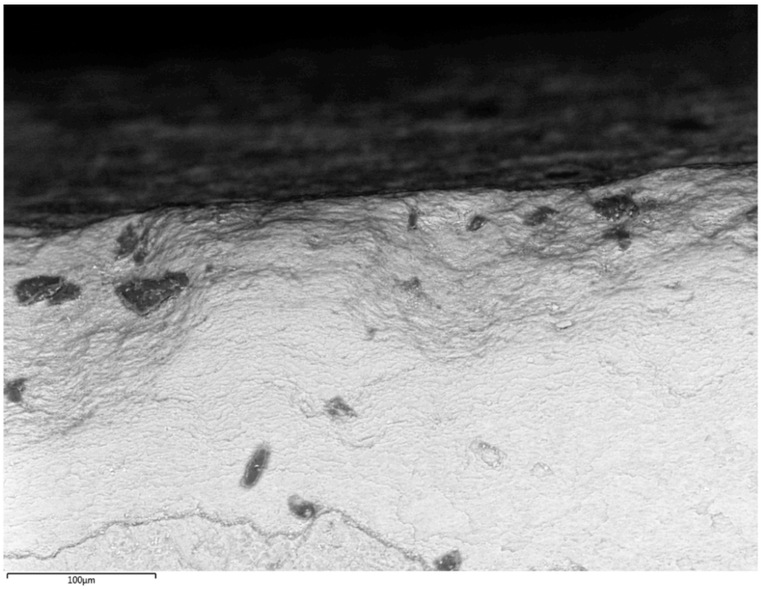

Figure 7.8: GC-001 – *Nautilus* shell edge (15kV, 30Pa).

GC-002 shows a number of distinct scores on the nacreous surface. The score shown in Figure 7.9 contains a significant amount of debris from the shell itself and is very similar in appearance to the scores generated in the experimental working stage (see Appendix 7). This score is clear evidence of human modification to sample GC-002. As with sample GC-001, possible plant residue is seen on the surface of the shell, with a concentration closer to the edges accompanied by mild acid dissolution.

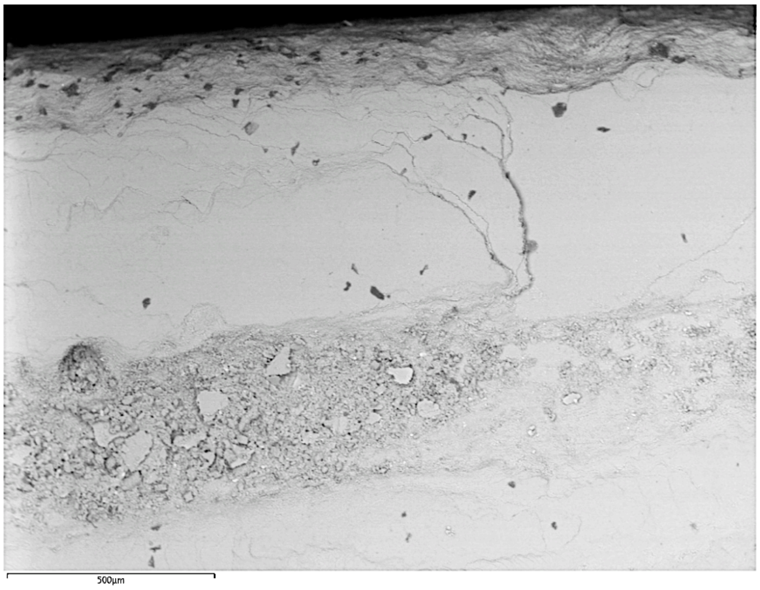

Figure 7.9: GC-002 – score mark on archaeological sample (15kV, 30Pa).

Further SEM analysis of GC-002 showed two distinct score lines on the nacreous surface of the shell: a finer score in the centre of the frame and a larger score at the bottom of the frame (Figure 7.10). The positioning of these two scores quite close to the edge of the fragment suggests that they were gestures related to a score-snap. The small amount of acid dissolution of this edge makes identification of edge morphology difficult to determine with any certainty, however, the overall trend of the edge is very straight and likely the result of a score-snap. The nature of these score marks (the larger and smaller in close proximity, trending in the same direction) is also found on the experimentally worked samples. In the experimental process, this score pattern was the result of the material used to score the sample having a number of protruding edges. The main edge of the scoring material was in direct contact with the shell and often, during scoring gesture, other more recessed edges of the score material would make contact with the shell surface and cause smaller score lines – much like the ones observed here.

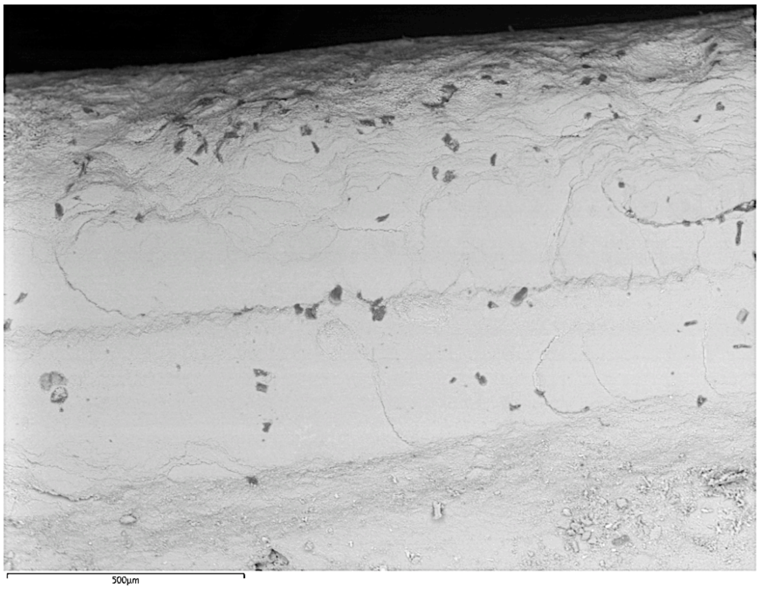

Figure 7.10: GC-002 – two score marks close to edge of sample (15kV, 30Pa).

Nautilus shell fragment GC-004 exhibited an unusual but clear depression in the prismatic surface of the shell (Figure 7.11). This feature does not appear to align with any documented taphonomic process and is likely the result of human modification. Score marks are apparent leading into the depression from a number of different angles, with traces of possible plant residue concentrated around this feature. The edge appears to have minor traces of acid dissolution and any other working traces are therefore hard to determine. This shell fragment was also noted to have fewer traces of acid dissolution than the samples described above. It is one of the better preserved of the Golo Cave fragments examined under SEM.

GC-004 also contains a section of shell where delamination has occurred and the prismatic layer has sheared off to reveal the nacreous layer beneath. The removal of the prismatic layer along the edge of this fragment makes identification of any working traces impossible. This delamination is common in multi-layered nacreous shell as this structure is susceptible to exfoliation and splitting due to weathering processes (Weston et al. 2015). This feature was noted on several of the Golo Cave fragments examined under SEM, with some being a result of weathering processes and others appearing to be directly caused by burning.

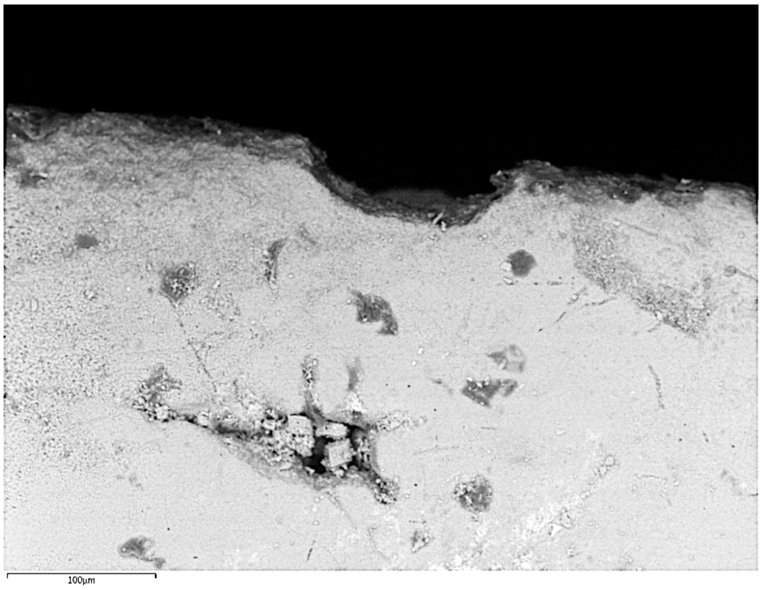

Figure 7.11: GC-004 – prismatic side view - apparent convergent scoring (15kV, 30Pa).

GC-005 was examined under SEM, but was observed as being significantly damaged and deformed. The microstructure of the shell appeared to be cracking and crumbling, with this structure being consistent with burnt shell (pers. comm. Szabó, 2016). This sample has also experienced significant acid dissolution over the burn surface, causing considerable smoothing of the edges of the fragment, making any identification of working traces impossible.

Under SEM analysis, Golo Cave fragment GC-007 featured a consistently smooth edge (Figure 7.12) not comparable with the smoothing noted above in samples that had undergone acid dissolution. This fragment appears to have been abraded. This sample may have been score-snapped, or may have undergone significant abrasion to generate this surface. As seen in previous samples (GC-001, GC-002), adhering residue is present along the surface of this fragment. This is once again likely to be an applied coating on the *Nautilus* fragment. This sample was also noted to have a small number of shallow depressions in the nacreous surface (Appendix 9). Their origin is unknown, but small adhesions in the centre may be another residue that has caused some degree of deformation in the nacreous layer of the shell fragment.

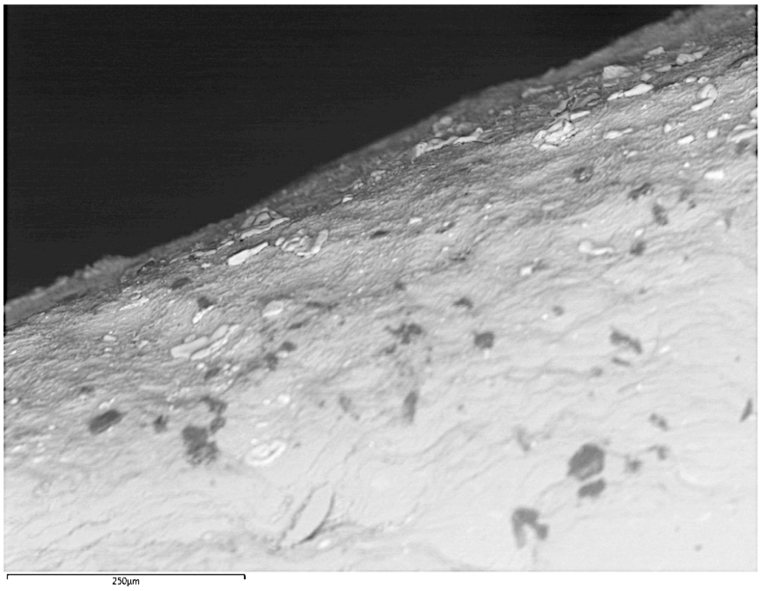

Figure 7.12: GC-007 – edge showing apparent abrasion (15kv, 30Pa).

One fragment examined under SEM, GC-009, exhibits characteristics of a possible calcium carbonate build-up. This occurs as a result of water seeping down from overlying stratigraphic layers, with calcium carbonate precipitating out and being transported down to lower layers where it adheres to calcium-based specimens (Zamanian et al. 2016). This process creates an outer layer of calcium carbonate, coating the shell, making the identification of any previous edge morphology impossible.

Fragment GC-012 is the oldest *Nautilus* shell fragment recovered from the archaeological excavation of Golo Cave. It is a septal wall fragment that exhibits significant delamination and deformation due to fire stress (Figure 7.13). As this is a severely damaged specimen, identifying any traces of working or other diagnostic features of the edge morphology is inherently difficult. This sample does, however, clearly demonstrate the high degree of delamination that can occur in a burnt sample of nacreous shell. This delamination is the result of organic components within the microstructure of the shell being destroyed and hence no longer facilitating cohesion between the layers (Valentin & Clark 2013).

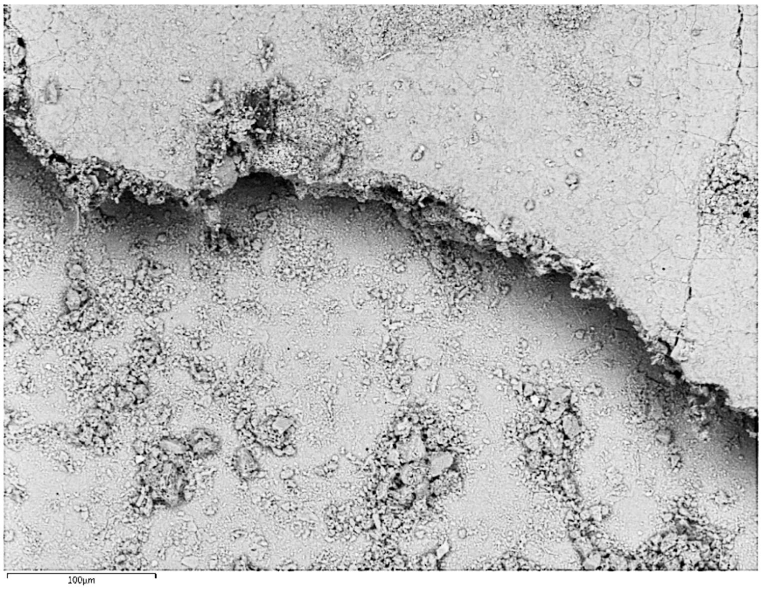

Figure 7.13: GC-012: septal wall fragment (convex side), burnt and delaminated (15kV, 30Pa).

The following chapter will discuss the results presented in the past three chapters, from the evidence of *Nautilus* shell use in Golo Cave, to the current and historical importance of its use in the region today – as seen in the Solomon Island context.

Chapter 8 – Discussion and Conclusions

A number of important findings were made throughout the progression of this study that generally related to the various edge traces of either working or natural breakage of *Nautilus* shell in contrast to those of archaeologically recovered samples of *Nautilus* shell from Golo Cave on Gebe Island, Indonesia. Much was also learned about the cultural significance and use of *Nautilus* shell in the Asia-Pacific region through an ethnographic examination of *Nautilus* use in the Solomon Islands today.

One of the main findings of this project was that some of the Golo Cave fragments recovered by Bellwood in 1994 and 1996 have indeed undergone working and modification by humans. This was evident through the examination of experimentally worked fragments under Dino-Lite microscopy and SEM analysis, followed by comparison to Golo Cave fragments also examined under Dino-Lite and SEM microscopy.

The key example of *Nautilus* shell working from Golo Cave was fragment GC-002. This sample had apparent signs of working (in the form of scores) that were visible to the naked eye. The origin of these score lines was believed to be human working prior to this study (Szabó 2013, p. 280) and, in fulfilment of one of the main aims of this research, this hypothesis was systematically tested and proven.

Figure 8.1 shows a sample of *Nautilus* that had been scored and snapped using basalt for 100 gestures. When compared to the archaeological samples GC-002 shown in Figure 8.2, clear similarities can be seen in not only edge morphology, but also score pattern. The parallel score lines noted in Figure 8.1 represent scoring in which two points on the surface of the scoring material were making contact with the nacreous surface at once. This pattern was noted on cut bone by Choi and Driwantoro (2007) and described as evidence of shell tool use. This latter assessment of the dual-scoring pattern has been questioned (Szabó 2013), as this style of score pattern can easily be generated using lithic sources, as noted in the scoring experiments (seen in Chapter 6.2)

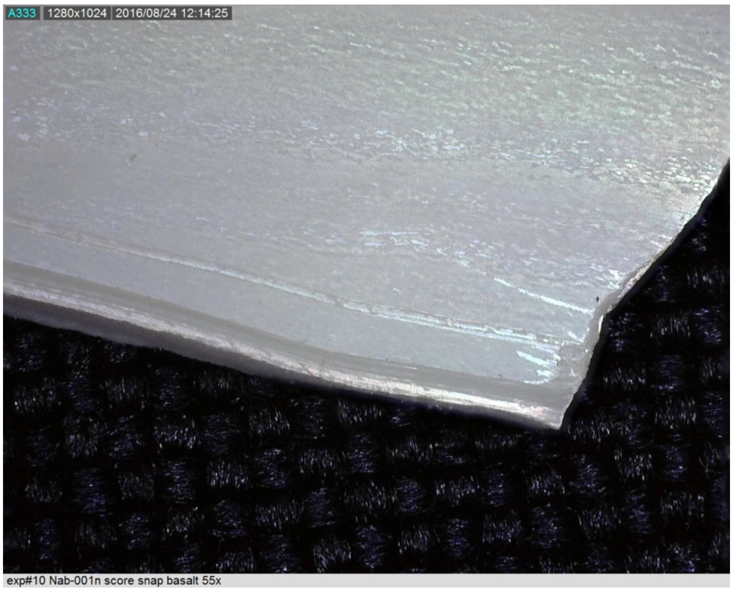

Figure 8.1: Nab-001n – *Nautilus belauensis* fragment score-snapped using basalt for 100 gestures.

Figure 8.2: GC-002 – *Nautilus pompilius* fragment (recovered from Golo Cave) showing clear signs of scoring and a likely score snapped edge.

SEM images of this sample show strong evidence for the scores being the result of human working. The scores show a high degree of similarity when compared to the experimentally scored samples. In addition to morphology, the main feature that can be easily correlated between the experimentally worked and archaeological samples is the presence of fine shell debris in the score. Under SEM microscopy, a very similar pattern of residual debris can be seen in the score on experimentally worked fragment Nab-012b (Figure 8.3) and Golo Cave sample GC-002 (Figure 8.4).

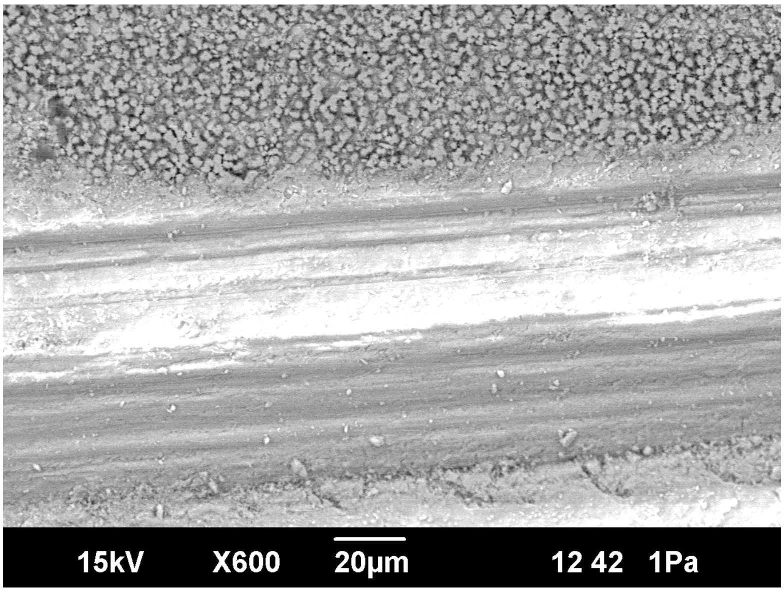

Figure 8.3: Nab-001g – *N. belauensis* fragment, score-snapped using chert for 100 gestures. Note the traces of debris in the score line (15kV, 1Pa).

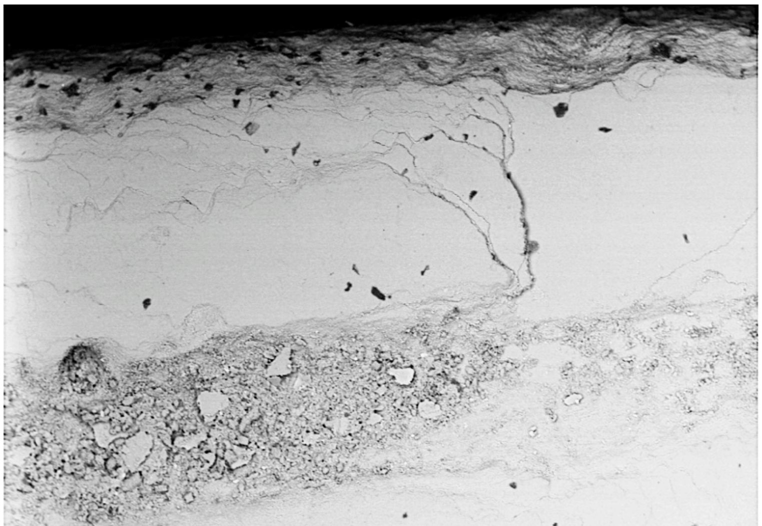

Figure 8.4: GC-002 – *N. pompilius* fragment recovered from Golo Cave. Note the traces of debris in the score line (15kV, 30Pa).

Golo Cave fragment GC-007 also showed traces of working in the form of an abraded edge. This was noted mainly through SEM analysis of one of the straight edges found on this fragment. The sample was selected for SEM analysis after appearing to have a straight, possibly abraded edge in the Dino-Lite examination of the fragment. This straight edge, when examined under SEM, did exhibit uniform rounding consistent with abrasion, as compared to the experimentally worked abrasion samples. The most comparable form of abrasion from the experimentally worked samples was the *Acropora* sp. branching coral for 100 gestures (Figure 8.5). The uniform smoothing of this edge is noted to be very comparable to the edge of Golo Cave fragment GC-007 (Figure 8.6).

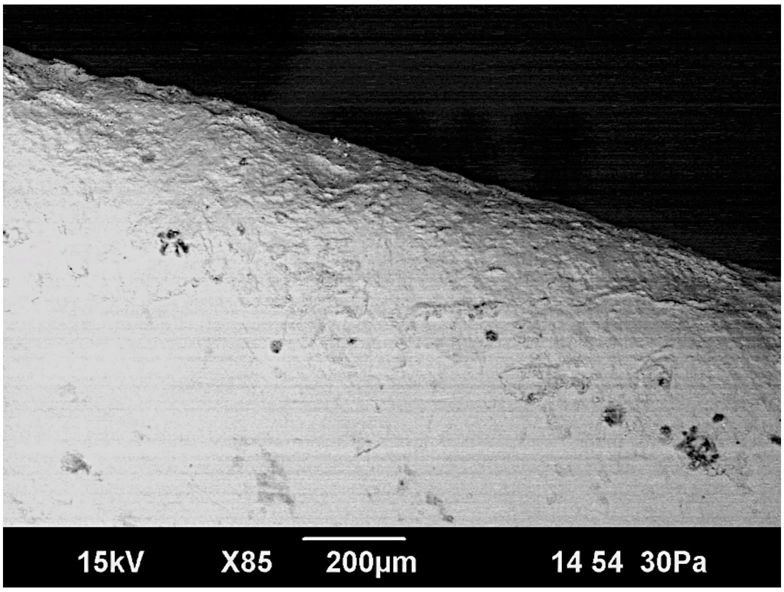

Figure 8.5: Nab-003 exp#25 – SEM image of *N. belauensis* after abrasion with *Acropora* sp. branching coral for 100 gestures (15kV, 30Pa).

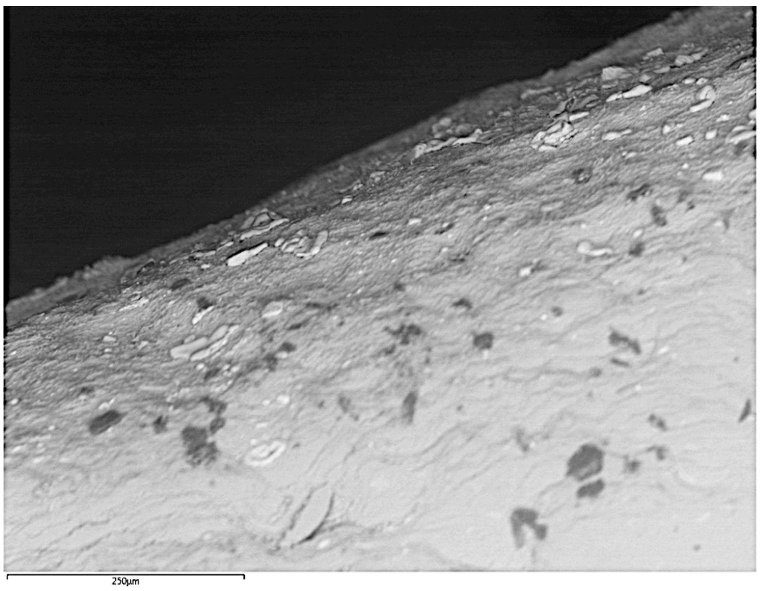

Figure 8.6: GC-007 – SEM image of *N. pompilius* showing abraded edge rounding with possible residue traces (15kV, 30Pa).

These findings are consistent with current literature regarding the presence of worked shell at Golo Cave. Szabó (2013, p. 280) and Szabó et al. (2007) describe the presence of worked *Turbo marmoratus* opercula as well as reduced examples of *T. marmoratus*, with a further paper by Szabó and Koppel (2015) describing the presence of modified *Scutellastra flexuosa* limpets in Golo Cave having been used as scrapers. The documented presence of other worked shell in Golo Cave suggested a strong possibility for the working of *Nautilus*, however, the main difference between these species of shell is that *Nautilus* is the only species of worked shell found in Golo Cave that would not feasibly have been collected as a food source (Szabó 2013, p. 280). This is significant as it suggests a conscious effort to collect dead, empty samples of this shell and work it without the incentive of food collection. This may represent an early cultural affinity with the *Nautilus* shell for artefact production.

The microscopy results for the INSTRON breakage experiments also revealed several important things about the edge morphology of samples broken through compaction. After examining the Golo Cave fragments and cross referencing them with the INSTRON samples, it became clear that most of the Golo Cave fragments had experienced natural fracturing along at least some edges. Examples of the three main edge morphologies discussed in Chapter 6.1 were noted on several of the Golo Cave fragments that did not appear to have undergone working. In essence, the Dino-Lite and SEM analysis of INSTRON fractured samples were able to aid in positively identifying examples of natural breakage on the archaeological samples recovered from Golo Cave. This proved congruent with the identification of worked edges found on Golo Cave fragments through the working and examination of modern *Nautilus* samples.

This project also examined the cultural significance of *Nautilus* shell, with a specific focus on the Solomon Islands. As one of the only places to currently work *Nautilus* shell for use in traditional art, the Solomon Islands presented a unique ethnoarchaeological opportunity to study not only the significance of this material in a cultural context but observe the way in which it is worked.

The interviews and demonstration conducted in Honiara, Solomon Islands, were able to give a clearer understanding of the importance of *Nautilus* shell to the Solomon Island people and give an idea of the possible cultural and social implications of using *Nautilus* for artefact production in prehistory.

In a practical sense, the Solomon Island people (both now and in the past) have used *Nautilus* shell to decorate both wooden artefacts (sculptures, canoes etc.) and other culturally important artefacts such as armbands and decorative accessories (see Figure 6.8). The logistics and techniques of working (as discussed with Peter Maepioh) formed a portion of the methodology for this project, but the cultural and economic importance of this shell gives a broader understanding of its use. Through the discussions with Peter Maepioh and Patricia George, it became clear that the traditional cultural aspect of *Nautilus* shell working has diminished with the introduction of Christianity and a westernised economic structure, meaning that the main reason for *Nautilus* shell working today is for economic benefit. Burt (2009, p. 50) describes the transition from cultural shell working and craftwork through to a style adapted to suit tourists' tastes throughout the Solomon Islands in the 1980's. This trend appears to have progressed into the 21st century, with a continued diminishing of cultural value in exchange for more profit. On reflection of its past significance, the *Nautilus* shell seems to have been highly valued as being important to activities involving hunting and war, however, the ethnographic record of this region seems to have broadly overlooked the specifics behind this association and its significance (Thompson 1995, p. 76).

The general methodology for this project was piloted by Szabó and Koppel (2015), with *Scutellastra flexuosa* shells from Golo Cave being compared to an assemblage of experimentally worked and INSTRON fractured *Scutellastra flexuosa* specimens. This methodology is systematic and structured, with great attention to the generation of likely traces on a certain shell type followed by comparison with suspected worked samples of that shell type. Due attention is also given to microstructural patterning and taphonomic modifications. An alternative methodology was used in a recent paper by Langley et al. (2016), which also sought to identify traces of working on

Nautilus shell fragments recovered from Jerimalai, Timor-Leste. Langley et al. (2016) also proceeded by modifying samples of a modern *Nautilus* and comparing the resultant traces with archaeological samples from Jerimalai. This study was conducted in a somewhat novel manner with very little regard to several important factors throughout the experimental working of the modern *Nautilus* fragments.

Firstly, very little detail is given regarding the initial reduction of the *Nautilus* shell used for these experiments. It is stated that the shell was broken via percussion with a hard surface, which may refer to freehand percussion using a hammerstone as easily as it could refer to the shell having been dropped from height onto solid ground. Given the unique micro- and macro-structure of *Nautilus* shell (Arnold et al. 1990), fracturing and fragmentation of the shell will vary widely depending on the amount and direction of force applied. As the style of percussion may generate different fragment types (as demonstrated in section 6.1), the lack of clarity on this detail casts doubt on the nature of the fragments generated for this study. It would also seem that Langley et al. (2016) use only one sample of *Nautilus* shell with very little, or no, repetition of the experimental working process. Given the idiosyncratic nature of *Nautilus* shell structure, lack of repetition may generate inconsistent and unreliable results. The variety of edge morphologies generated through the INSTRON-fracture experiments in this project highlights the need to assess multiple samples. For example, fragment Nab-004a (Figures 6.1, 6.2 and 6.3) was found to have all three of the most common edge morphologies noted in this study.

Secondly, Langley et al. (2016) state that experimental working of *Nautilus* shell fragments was conducted through “vigorous grinding using a back-and-forth motion with a fine-grained sandstone block” for ten minutes. When generating traces for comparison against archaeological fragments, subjective descriptions such as ‘vigorous’ are unable to accurately describe the process of working conducted on the shell and make accurately replicating this experimental methodology impossible. Weston et al. (2015) make note of the imprecise nature of time duration as a measure of working intensity and instead state that the "number of actions" provides a more precise result. In effect, ten minutes of vigorous working for one individual may constitute a significantly different amount of working and abrasion than ten minutes of vigorous working for another individual. For this reason, the results obtained through time duration technique cannot be replicated with any certainty and hence cannot be verified. The flaking and drilling experiments undertaken by Langley et al. (2016) make no mention of either time duration or actions required to perform the described task. This once again makes the following of this poorly described experimental design impossible. This shortcoming has been targeted and remedied through the methodology of this current project, with systematic working techniques clearly described and documented to allow for easy replication and verification of any of the results presented in Chapters 6 and 7.

Thirdly, Langley et al. (2016) refer to a process of "pressure flaking" as a means for generating a notch in the edge of a *Nautilus* shell fragment. This technique is not described in any detail, making replication of this experiment impossible. The well-documented process of pressure flaking generally refers to a specific technique used in lithic working to generate a sharp or fine edge/surface (Kelterborn 1984). This technique generally involves a pointed tool held level with (and touching) the thin edge of a lithic core or artefact, with the application of pressure causing a flake to shear from the edge. Pressure flaking in this sense on the very fine edge of a *Nautilus* shell fragment would be difficult, if not impossible, to achieve and would be a very unlikely method of working this material. There are no apparent ethnohistorical or archaeological precedents for the use of this technique in *Nautilus*. The results state that the notch was generated through pressure flaking on the posterior side of the sample, indicating that the initiation point of this notch is not consistent with the widely accepted definition of a pressure flake as stated above. In essence, exactly what working task was performed, how and why, is unclear.

Considering these flaws in experimental design, the interpretations drawn by Langley et al. (2016) about the working of *Nautilus* shell fragments may not be accurate. This may in turn have implications for the accuracy of conclusions drawn about the fragments from Jerimalai, Timor-Leste. The mention of specific lithic sources being used to work the archaeological *Nautilus* samples is based on the working traces acquired through the experimental working of these samples using a method that is both poorly described and impossible to replicate. This calls into question the viability of this result and hence, the accuracy of the general conclusions made by this paper. While the fragments may still have been worked, the materials and method of working cannot be accurately interpreted based on the Langley et al. (2016) paper.

Through careful consideration and planning, several of the methodological issues mentioned above were avoided in this study, with high degrees of repetition and specificity regarding the experimental working of *Nautilus* shell fragments. In this way, it is hoped that the methods of this project can be easily repeated and adapted for use as a general methodology for the generation and identification of working traces on any kind of shell used as a raw material.

This project has found that the Golo Cave assemblage excavated by Bellwood in 1994 and 1996 does contain fragments of worked *Nautilus* shell, and that these samples of worked *Nautilus* were most likely scored, snapped and/or abraded into shape using a variety of lithic and non-lithic materials available to inhabitants of Gebe Island in prehistory. These findings are consistent with the current published works on shell working in Golo Cave.

The oldest sample from Golo Cave, fragment GC-011, had a ^{14}C age of 30960 ± 190 BP, but was in very poor condition, making the identification of working impossible. This was also the case for fragment GC-012. GC-012 was recovered at 200-205 cm depth, with a ^{14}C age of 28740 ± 474 BP, showing significant delamination and very poor preservation. The burnt nature of the shell made identification of working impossible to determine within the scope of this study. Other older fragments included GC-009 and GC-010. These fragments were aged at a ^{14}C range of 29330 ± 190 - 30960 ± 190 BP. GC-009 is a septal wall fragment, and GC-010 is a fragment originating near the umbilicus of the shell. Neither of these fragments appeared to show signs of working.

The chronology of the Golo Cave fragments shows that the samples with definite signs of working are relatively young. GC-002 showed the most prominent signs of working (Figure 6.20). This sample was recovered from 40-45 cm depth, with a possible ^{14}C age range of 3255-3680 BP. GC-007 also showed definite signs of working. This fragment was significantly older, recovered from 95-100 cm depth, with a possible ^{14}C age of 10210 ± 60 BP. These fragments show a definite history of *Nautilus* shell working in the area spanning a range of around 7000 years. This working of *Nautilus* over time may indicate that the older samples are also worked, however, without further analysis of working traces on burnt shell, this conclusion cannot presently be drawn.

This project also furthered the methodology piloted by Szabó and Koppel (2015) and Weston et al. (2015), with generation of working traces and natural breakage patterns followed by comparison with archaeological fragments to aid the identification of worked archaeological samples. This shows that the methodology used in this study can, in effect, simplify the identification of worked or unworked shell samples upon recovery in an archaeological context. This project also examined the practice and context of *Nautilus* shell working in the Solomon Islands, finding that a transition has occurred from the culturally significant *Nautilus* craftwork of the past to more economically significant *Nautilus* craftwork today.

Future direction for this research field would counteract some of the limitations encountered throughout this research. One of the main limitations of this study was the lack of analysis on the nature of burnt *Nautilus* shell and how working may appear after incidental burning has occurred. This made identification of working on burnt samples impossible to address here. Further research into the appearance of traces on burnt shell would make the identification of such traces significantly easier.

Given more time and resources, this study could have possibly benefitted from direct dating of the *Nautilus* shell fragments recovered from Golo Cave. This may have provided a clearer result on the timeline for the working of *Nautilus* shell in the Golo Cave context, thus enabling for a more accurate history of the working of this shell in the region to be established. This is a potential area of future research as it may shed more light on some of the samples that were in a relatively large age range bracket.

Another area of limitation that may have scope for future research is the ethnographic variation of *Nautilus* shell use across the Solomon Islands. With more time and resources available, interviews could be conducted with a larger number of individuals to gain a better understanding of the varying traditions of *Nautilus* shell working and its significance in prehistory as well as in a modern context in places where selling to tourists is not commonplace (as is the case in Honiara). This would provide more detailed insight into the use of *Nautilus* shell and its variation between different communities throughout the Solomon Islands.

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Appendix

Appendix 1 – Interview with Peter Maepioh

Kat Szabó (K): So with the learning how to carve or you being the carver in the family, normally do you learn from a father or older relation? Is that normal?

Peter Maepioh (P): Ah, very good question. Lots of people in Marovo Lagoon they can do carving, very clever. But you can learn, from other people. But my tribe that I came from, they never learned. Nothing is true blood call. So we just work. We never learn from people. Come from our tribe. Before, you know, during head hunting time our people also start to carve before and they wish it by, you know, their god and the spirit and until the Second World War they can sell things to the American to get money. After the Second World War, they continue until today. And they all dead, finish. But their children continue. But when you go to Marovo this time you can see lots of people, every villages, they can do carving. No place to sell carving, very hard. But you can make carving, you can make money out of carve. But where to sell all our product? Very hard here in the Solomons. No more plenty of tourists come to the Solomons, so very hard. But we keep busy, we still working. Like shell money, in Malaita, I can see these people they can sell a lot here in this country because they use it as a custom. For the right price, so no problem. But the carving is different, you know, we never use carvings ourselves, but we sell it to the other people outside, so a bit slow

K: Yeah, I guess like with the shell money you have a custom shell money and the tourist shell money, so if you're selling the carving, is there still custom carving?

P: Yeah, some of the carving we make is traditional, the custom, have historian make a notice but contemporary carving is just to get money, just to sell it

K: Just to sell, yep okay

P: Two different kinds, one for more traditional or custom and one contemporary just to sell, you know, get money

Gavin Parkinson (G): What's the difference between the two? Is it just different styles or is it made differently?

P: Not different style, not very much in different style but our ancestor before, they used this for headhunting, the spirit, very powerful. That's how they can won the battle when they go to war. Because they use this as a devil, as a god

K: Yeah and I guess with the tourist ones, you see all sorts of different shapes

P: Yeah and not very plenty from my people in Marovo Lagoon they can do this traditional ones. I don't know, maybe one or two, and [unknown] one, I can do this one from my uncle, he told me to do this so I can use it every time. When we go out from Solomon to any festival outside, that's the only thing I can get money from. Our ministry, they bought it from me and they give it present to the government outside, this traditional head. So only I can make like that. So it's very interesting, very interesting. But not now, not today. Before. We never use this as a god today, it's finished. When the Christianity came, then all this is finished. But we can still make that for, to earn money you know, to get money, this day

G: I was going to ask, when you said that you were taught by your uncle, and that he had sons and that you had lots of brothers, why was it, is there a reason that you were chosen to learn the technique?

P: It depends. It depends on the boss. Like, for example, when we want to put up a chief, that old man, that chief, tribal chief whatever, or maybe parliament chief, he can call anyone in the family because we all have the same right. So what he think, he can call one out of the draw and he become chief the next time. It's the same, exactly the same as what they did to me because he have his own children and his second brother have children, boys and girls, and my dad is very young, he's last one in the family but they give it to me. And I have my first brothers, maybe four big brothers, but he didn't give to them. He called and said 'Peter you take over my work and I give it to you' with my dad, so that's all (Laughs)

G: That's very lucky, that's good

P: Very lucky

G: Where do you get the actual *Nautilus* shells that you use for your inlay, where do you get them from?

P: From the people. These shells from the sea, they float and come ashore and the people pick them up and they know that we are carvers so they come and sell it to us. But for us to get this *Nautilus* shell is no, from somebody

G: Always from somebody else, yep

P: The people who cannot make carving, they can get money out of that *Nautilus* shell so when they pick it up from the beach, they say 'very lucky, we can make money'

G: Yep. So no shells are traded from outside? It's always from within the Solomons that have washed up on the beaches here or do they come from other places like the Philippines?

P: All from the Solomons, maybe outside like the Philippines, or any more countries outside, maybe they also have this because they come from the sea

G: So they're only ever found washed up? They're not actually targeted by fisherman at all?

P: When the *Nautilus* shell died, when the flesh is finished, because the flesh of the *Nautilus* shell is very much eaten by fish. So when the flesh is finished, the *Nautilus* shell will float outside this. The wind, maybe the waves, and down to the shore

G: What sort of tools and what materials are the tools made of that you use to work with the *Nautilus*?

P: We have a different file, like three corner file and a flat file, and round file. We use all these different types of files to make a different design out of *Nautilus* shell

G: So they're all just metal files?

P: I'll show you today

G: When you very first learnt was it with metal files, what tools were being used when your uncle taught you?

P: Because we cannot make our own tools, so what we used to do is that we cut up all these very old bush knife, and cutting in the small in the short and we make an edge, you know, for the handle and then start to make carve Now, a bit different, today it's good. We can get tools from somewhere, from many, many places. But before very hard. So we can also create our own tools. We just make them ourselves, not very good but you know. Like sandpaper for example, sandpaper, we have no sandpaper before, so we use a local leaf out from bush. We can go and cut the branch out of a tree then put it in the sun, and when the sun hits and makes it dry, we use the sandpaper.

But today because, you know, Chinese and European bring all these from other countries, so we use this sandpaper now today, but before we just use a leaf out of a tree

K: Because when we find things maybe in the archaeology, it's going to be using the old tools and the old techniques, so we've been trying to think about what are the possibilities, I know, say in Polynesia, they use shark skin sometimes for sandpaper. Drying the sharkskin and you said there are leaves and sometimes pieces of coral you can use as a rasp. And these are sometimes things that we find in the archaeological sites but we don't always understand what they're used for

P: Yeah, just like the glue, before we have no glue. But have a fruit. We call it local name, we call it *tita*, T-I-T-A. *Tita*, *tita* fruit. This is very best, and we still use it today. Because a waterproof one. When our canoe have, you know, broken part or something like a leak or something, we use this local fruit. It's waterproof, very strong, forever. We use this as a glue, but now, you know, glue is coming and so it makes it easier for us. But this *tita* fruit, we used it to cover all the pieces that we make glue out of the *Nautilus* shell to cover every place that we use a file, then after when it get dry and we use sandpaper and make it very smooth and you cannot see it.

G: That's great. So what do you do with the fruit to turn it into the glue?

P: We just crush it and paint it on the *Nautilus* shell

G: That's brilliant

P: If I have one back home, I will show you. Normally we have a glue from the shop but we still apply this after we put the glue and we apply this after, to cover every design

K: Can I just jump in? I have one more question. So when you are given or you buy the *Nautilus* shells from people who find them, you know, the pieces you want are often very small or that you're shaping and the shell will be whole, so do you break the shell into biggish pieces?

P: Yes. Before, we have no tools like today, so we just use a knife, bush knife, whatever, a knife. Then we just cut it through the biggest part or something then our carving is used to make a groove. On our carving, where they get groove in our carving, that's to put shell inlay in there. So we can make the very right size, cut the very right size of the groove, then we make a design out of shell and we put inside the glue on and after we use this local fruit to put more, last one and when it gets dry, maybe after one day, okay use tool to smooth it out, polish it. That’s all. But yes we cut this shell into small pieces. I’ll show you

K: Do you use those bigger pieces from the outside of the shell? Because it’s also got the thinner, you know, the walls inside the shell, do you also use those for inlay?

P: Not very much, because very thin. Very thin. But we only use outside part, a bit thick. The round part of it. This bottom part, that’s round like this, we can keep it sometimes and sell them for the tourists. That whole part, the bottom part. But if we really have no sale, then we will cut the bottom part and we can get the thin one too. It’s very special. This shell is a very special shell. Today, lots of people now here, when you go around to the [Auki] area, you can see some earrings and necklaces, it’s better than [unknown]. Beautiful

K: Yep, it’s a great shell

P: So we can use all parts of that shell, the *Nautilus*

G: Good. When you were talking about the different styles from the different areas, are there different styles between different family groups or tribes?

P: Tribes

G: Between different tribes?

P: Tribes, yeah

G: So all the families within a tribe will make roughly the same style?

P: Yes. Well, that’s a very good question. Not everybody. Because some of them will, they do not understand how to make these types of things. Some of them can do it but if they just sit very close and next to the one who can make this one, they can learn and start to do this one and they can do it. My tribe where I come from, we didn’t learn very much, I told you today, but this maybe come through our blood. So, for example, if my son, he never carve but he want to do carving, he can do it. Then sometime he might ask me ‘Dad, what are you going to do, with this part of this carving?’ and I say ‘You do this, like this, finish.’ He can continue that. Yeah, very easy for us. Like too many people in Marovo Lagoon, they know that carving is good money and this only things that can earn money from my place because here resources, yes they have resources, but we cannot do this out of money, money out of resources, so people now, even the students that go to the highschool or university from 6 to 7 they come home and they never do anything but they come back to the carving. So they can easily come sit next to us and you know, try to look and learn. And we help them. Because is the only way we can get money

G: Yep. So it doesn't matter if they're not related? You can teach anyone?

P: Yeah, help them. Some of them are very poor, any have money for the school fees for children. So you know, we have to support them, we have to help them, so they too can get money out of that

G: Was it always the case that people that knew how to carve would teach anyone in the village that wanted to learn or before was it only teach relatives?

P: Yeah, because when they start making carving, the carving maybe not look very good, first starting. So we will help them, 'you make this like this', you know, 'cut this out' and you know, 'keep this one', 'make it shaped like this', all this and also with the inlay work, we teach them how to make the inlay work. We can help them to show them which is the best tools, the size of tools that will help you. Everything like this we help them, help the people

G: There's been a few pieces that we've seen around that had the little shell money beads inserted into them as well

P: To the carving?

G: Into the carving

P: Yes

G: Alongside the *Nautilus* inlay, there was the shell beads

P: Yeah, when we go to my house, I'll show you the shell beads that I use to put the eye of the carving, and maybe decoration for the war canoe for any part of the carving, I'll show you. I always bought these in the central market here. Malaita ladies, they sell this. So we can do it by *Nautilus* shell but sometimes we think that we are supposed to help other people. So when I run out of these beads, I go to the central market and look for, you know, for the string and I bought something like 100-150 dollars for one string, just to help them get to money

G: Yeah, sort of helps it go around, yeah. That's really good

P: Yeah. I think here, maybe not very plenty but I can say a few people, I help them to, you know, how they can get earn money. You know this because seven years now I'm in town, in Honiara. I can see many people they're crying for the school fees for the children. Very sad. So that's why I do this to

K: To help them out, yeah

G: So with the shell money beads, like you were just saying they're the ones from Malaita, are there different types that you use?

P: Yes

G: Are there specific types of the shell beads that you use and not others?

P: No, they use the same type how to make. You asking how they make this?

K: No, no. I mean in terms of the ones you chose because they're, you know, for the Langa Langa money they have different colours and slightly different types, so are there types that you prefer to use?

P: Only white colour

K: Only white, okay

P: Only look for white colour… So that, you know, we can make the white colour out, stick out of the wood but if the brown that they use here, brown shell, you know

K: Yeah, not distinctive, yep okay

G: So with those ones where you use the shell beads, was that used in the traditional style as well or is that only for the ones for tourists?

P: Yep, no it is also used from the traditional. Like Malaita, they from traditional, so we use it from traditional wood

Edna Bellow (E): That's right. That's what I've learned, when I look at the books that the researchers have wrote, some of the information is not correct. Because like this sort of inlay shells are only practiced in Santa Catalina

K: Right, okay

E: In Santa Cruz Islands they don't use inlayed shells on carvings. So they are different. Only in San Cristobal and western part of the Solomons did shell inlay. Malaita is not really, they try to adapt the western style. But it's more..

As they continue to make, it started to become perfect at the western province. But it's not their style, it's western province

K: They just copied each, yeah

E: Just imitating. But not like before, in Isabel they even did shell inlay. I think they have connections with the western province during the headhunting days

K: Yeah and I was told too that there's quite a lot of *Nautilus* that wash up on Isabel so often that would be one of the big places where the raw materials came from, even if they weren't carving, they were supplying the *Nautilus* shells to western province

E: Yes I think scientifically, the current, you know, there's a special current from the eastern Solomons between Isabel and western part (indicates on map)

G: When we were talking about the modern tools that you use now, versus the older tools that your uncle would have used, when did that transition take place? When did they go from using the traditional older tools to the tools that you use now?

P: During, well I can go back to the Second World War. I don't know where they get the tools to make these things. But before Second World War, there's some piece of iron that they use also for the carving, I understand. But after Second World War, we can get a lot of different tools from you know, the European people came to the Solomons. And until today, before we use to make our own tools but now we buy our tools from outside. I can say now it easier for us, very easier, because different types of tools and also electricity tools. Electricity also came in so, make everything much easier

G: Yeah, that's fair enough. So when you were making your own tools, what sort of different types were there?

P: Like we can cut piece of iron very good, solid iron, and somebody came before teach us how to make a tools, own tools. A lady from [unknown]. She came here and show us how to make a tools. Burn the piece of iron very hot fire, well too many work (laughs). Not the perfect like what we have today because today, you know, everything is okay. Very good. So our living before very hard just like tools too, very hard but we keep on making our, you know, our income. Carving and sell them, not very good like today. Today, tools is very perfect. Carving is very quality

G: Yeah definitely

P: I'm a bit worried about this, you know, we start talking about this in our country today, copyright. What Patricia said, I'm very happy about what she say to us, because lots of people can do same thing but the culture and the tradition is different. So lots of people can make this one, they can tell a different story and I'm not very happy about this, because my tribe or where I came from, our ancestors, our god, our spirit, we can make this from us so I think if we can put across the real story about these things, I like that one. But if somebody copy this and make, for example like, traditional head, where I can do that one, somebody copy and they can make it and tell European people a different story, I'm not happy about this

G: Absolutely, yeah definitely

K: Because it's not their story

P: And they will adopt this story from different people but not exactly the right one. I'll ask Edna, do you have any book in museum? She said 'No, I don't know'

K: Well this is part of the problem that we've had is that, you know, there's lots of literature from the, you know, the British colonial times and the early missionary writings about the Solomon Islands and say for the shell money of Langa Langa, there's lots of information going right back to about 1800's on these are the shells, these are the tools, this is how it's made, you know, good descriptions from different people through time. Whereas when we've gone looking for information on the *Nautilus* inlay carving of western province, we have found hardly anything. We find photos and you know, that say this is from the Morovo Lagoon or that's correct but no one really describes any of the detail, none of the processes described, nothing and I found that really surprising. Especially given how much there is for somewhere like Langa Langa and I'm not sure why that's the case but that's why we thought well we really need to talk to someone who knows because there's so very little in the literature

P: That's why I'm talking about something to talk this and to put in where that supposed to be. Because when you go to this place Caligarina today, you can see lots of people selling the things like head and *muzu muzu* and you say, if they talking about *muzu muzu*, there's another word that not belongs to Marovo Lagoon. In my tribe where I come from, I'm from Caligarina tribe, I'm from Caligarina, and Caligarina can also make these traditional things, during headhunting times. And when Caligarina people, like my uncle give to me, I

can tell the real story about what is this. But when you go around here, for this place at Caligarina, you can see lots of head, like you know, they call them *muzu muzu. Muzu muzu* language is from Roviana, not from Marovo. From Roviana. Different part of west. Marovo we call it *Totoisu*, this head, *Totoisu*. This *Totoisu* is two different word- one *toto*, and the other one, the second one is *isu* and then put them together and become *Totoisu*. And have a meaning out of these two words. But people here they cannot tell you what the meaning of this, because this is not belongs to them. So I try to put this straight, so that people from overseas or museum wherever in the world, they can understand what this and what this for and where this come from. You know? So we're talking about maybe about three times we have a special meeting here in Honiara. I joined this meeting. We want to put this back in the right place. If somebody want to make something like copyright, they must get permission to do this. And I am very happy about this.
Very sad, it's very sad here different people they don't know how, you know, they don't know about this, they're just telling a story to the European people just for tourist to buy this kind for the money

G: Yeah, not the real history

K: Next year I'm going to be going to spend a few months in Europe looking at some of the things in different museums, so definitely things from the Solomons. Mainly what I'm looking at is shell valuables, different types from different parts of the Solomons but also often there's shell inlayed so I'm, you know, taking photographs and recording the details. And also often I have a small microscope that plugs into the computer so that I can see very close up the details, so you can sometimes see the marks that the tools and it can help to identify the type of shell if it's not very clear but you know, sometimes the information with the object is good and sometimes there's very little or it's clearly not accurate. You know often you read it and you just go 'well that can't be right', there's a mistake somewhere. So it would be really good after I've done that to sit down and show you some of the photos and get your opinion on some of those. Would be really good. So I know this one, I was in England very briefly at the beginning of this year and I looked at some things and I know that there was a, it was actually an overmodelled head. So it was a skull, a human skull and they had put, what was it? Like it may have been the nut that you were talking about before, over the top

P: To cover

K: To cover. And they had used the *Nautilus* inlay and put it on the designs on the face. So skull, nut, then the *Nautilus* designs. So I'm just trying to find the, I think I have photographs, although I don't know if I have the whole

P: And this from western part of Solomon Islands?

K: I think so, I'm not sure that I have all of the details for that because they just asked me to take some photographs, so I didn't write down all of the details for those

P: Because I remember last year, somebody from western, from Marovo, they use the exactly the same thing like you're talking about. And this is probably the patella

K: Oh really? Okay

P: So you know what they do is that they go to the tribal site and find this skull and [unknown] and they say 'don't do that'

K: Right. I think I've got the details

P: Because some skulls very very special, they're from our chief, you know, big head of our tribe, they can just grab them out and you know, so not very good, people not very happy

G: Yeah, definitely

K: Okay. I don't have all the details for that one, I could probably get it. I only have the number of the.. You know, because everything in a museum they get a special number with the record, the accession number, so I have that. And it just says Solomon Islands so it doesn't look like there's detail but it will be old. It won't be new. So it will be from at least the early 1900's but probably from the 1800's. And there were.. A lot of the pieces of *Nautilus* inlay were the same sort of shapes as you see on the carvings but they also have eyes that were made of *Nautilus* as well so they were a different shape. I'll probably need a little bit of time to find things so I won't hold you up too much now. Actually more sensibly, what I can do, I've done this before for various other people that I've known and worked with. I've done this with people from northwest Australia, Aboriginal people, where I've seen stuff in museums. So what I do is I get all the information and I take photographs and I make a booklet and sort of give them all the information so that they can see exactly what is in the museum. So maybe I can do that when I'm there next year and give you the details but so that's an example of one of the photos

P: Yes

K: So this is with the microscope. So this is that sort of the putty nut and the *Nautilus*

P: Before the glues come in our country, we use the same nut, what you call *tita*, the fruit yeah

K: Okay, yep. And I bet that this is a type of clay that they've used, generally and then they've put on the tita where they want to put the *Nautilus* pieces

P: Yes, to hold it. Yeah, in here, in Honiara, I try to ask people how I can get the book for whatever, the pictures of the older things before, like traditional things, where I believe is almost finished now. I try to get the book for different designs of shell money. What I'm talking about is maybe different from the shell inlay. I'm talking about the, you know, the clam shell, very hard stone. Today somebody from Langa Langa down west of Honiara, nearby where we live, they can make this. This book, I know and I believe this is from western part of Solomons. But before, long time ago maybe their father about these different designs of this clam shell flat, big different designs, customs

K: Are these the big clam shell, like the [baraba]?

P: They make out from this big clam shell, the baraba what they call. But this book, I really like this one. Very hard to find here. I don't know where they print this book. Maybe easy to find in different countries or not? In museums?

K: Often they're published by museums, but often museums don't print a lot of copies so they can be quite hard to get sometimes. But sometimes you can still get them from the museum but often I get them from libraries and scan them

P: This guy who hold this book now in West Honiara, they did not allow this book, for us to see this book. Because they make different designs of custom shells from this book and sell, they get very big money out of this. I really want to get one. Because this is from Western Province, from Marovo and Roviana but they didn't want us to look for this book

K: I'm trying to think of… So this is a book…

P: Bit thick. Thick book, not very thin. Everything there

K: Is it an old book?

P: Very old

K: Very old book, okay. I'll have a think. I'll have a look. There are a few very old books. I don't have copies but I have some like photocopies of sections.

And you can always get them through the libraries in Australia so you can see and then if it’s useful you can copy

P: [unknown] forget the name of different designs, you know, from picture, from all shell money. From my you know, from ancestral, so I would really like to hold one of this book

K: Is the book just for Western Province or the whole Solomons?

P: What I hear from people is that they say this is from western part of Solomons. The book that the guy own in his house. Very hard for us to see this book. He did not let us to see this book. Maybe came from his dad I think. But his dad already died so is old book

K: Right, okay

P: Different names and different designs with all the traditional things. If you have this book you can see the pictures and the name of that things and the work of that things. That’s what I want to know. Because I believe I am part of this book

K: I’ll see what I can find because I certainly know some things, some old books and papers where they go through and they have different designs and they have the names. I can’t think of a whole book that’s really on western Solomons but

P: If you can get piece then we can put mine together

K: That’s it. Yeah. I could just try and pull together all the information. Yeah. Okay, I will do that

P: Yeah, okay. Thank you very much

K: Also with some pictures of the, some of the old things that they have in the overseas museums so you can see those

P: I went to Auckland in the, you know, the big museum and I try to look around. I can see some things like custom head, like *muzu muzu* or whatever, called totoisu. Very old. The statue rotten. Part of the head start to out and also one big long wartime canoe, maybe you’ve seen this one before

K: I have, it was amazing

P: I like it, very much interested to see this old how they work before, from my ancestors. Very good

K: Okay, well I'll see what I can pull together because I know I've got some bits and pieces but it will take me a little bit of time to go through all of the files to find

P: Don't rush

K: Better to do it properly. Excellent, okay

Appendix 2 – Interview with Patricia George

Gavin Parkinson (G): We've seen a lot of the inlay things around, is there anything else that you know of that *Nautilus* is used for? Are there any other uses for *Nautilus* around that's just not inlay?

Kat Szabó (K): Yeah sort of custom craft, like it's most well known for being used in the, particularly the Western Province carving and inlay but do you know if *Nautilus* shells are used for any other custom craft in other parts of the Solomons?

Patricia George (P): Yes actually *Nautilus* is used in every crafts in the Western Province but could be in other parts also they used *Nautilus* shell but where actually it originated, no one knows. We have to do more research on that, but from my experience, more *Nautilus* shell is used in the Western Province and from some historical books that I have come through, like shell from Isabel they use *Nautilus* shell also. Central Islands yes they also use, like when I'm talking about Central is Florida Islands like Nggela, Savo, they do use *Nautilus* shell too. Also in Santa Catalina they also use *Nautilus* shell but more on that shells that we've looked at yesterday. So I'm not sure when do they start using *Nautilus* shell

G: Yeah

K: Okay. I guess I should probably explain a little bit of the background to why we're asking any of this stuff anyway right because I'm an archaeologist and Gavin's sort of been working with me on his thesis and in some of the archaeological deposits that I've looked at, I've found small pieces of *Nautilus* that I think are cut but *Nautilus* is such an unusual shell if you look at it under the microscope, it's completely different to other types of shell because it's deep water and the shell is designed to be able to go down to really deep and so where other shells would break with the water pressure, *Nautilus* is like almost engineered to be able to withstand water pressure. So when you look at it under a high power microscope, the way that everything is arranged is completely different and it breaks differently to other shells a little bit. It's unusual. So basically as an archaeologist, we don't understand *Nautilus* very well as a material and I can look at these pieces and say 'well I think these are cut, I think they're not just broken from being in a site for a long time'. But in order to make a believable argument, we need to do experiments and we need to also, one of other tactics is actually talking to people who make artefacts from *Nautilus* and getting their expertise. So that was with yesterday and how it breaks, you know, what works, what doesn't work. What are the best techniques because that helps us to know what to look for

P: They don't know that that piece of, like cutting the right place

K: Exactly

P: If this is the right size, so yeah very smart
K: So we learnt a lot from that yesterday and actually the way that he was breaking the shells is what I, just from looking at these ones from the archaeology I could see the same traces so that makes me feel more confident that these are ones that have been, people have shaped for artefacts. Now some of these are from New Guinea, from three and a half thousand years ago. So you know Lapita?

P: Mhmm

K: Yep so they're from the earliest Lapita sites in New Ireland but we also have some fragments from much earlier from a site in the very eastern Indonesia, close to the bird's head of western New Guinea. So current on Papua, and they are 30,000 years old. So seriously old. And this is a cave site and there's shell midden. There's also some shell artefacts and other materials so you know this one, the big green snail. You know the operculum, that sits in the yep the big round. They have used that and they have a hammerstone and they knock off flakes and they've been using the flakes like stone tools but from the

P: From the *Nautilus* shell

K: From the yep, from the big two, from the green snail, so and they're 30,000 years old. It's very old shell tools but there are also some little pieces of *Nautilus* and because they're deep water, we know that, you know, the other shells there were probably collected for food initially and then they used the shells for other things but for the *Nautilus*, they're not collecting it for food.

They're just collecting the shell. So because it's so early that's actually quite, that's an interesting discovery. That they're sort of just deliberately collecting empty shells to make artefacts but we really need to understand these fragments a lot better and know how to understand the surfaces under the microscope and what's evidence of cutting. So I mean, so what Gavin's doing is sort of feeding into a lot of this, us trying to understand the diversity of uses of *Nautilus* and the sorts of evidence that we might see on things from archaeological sites. So hopefully that all makes more sense as to why we're asking these questions

G: Bit of the background

P: That's right, yeah

G: So we've seen sort of more like the ones we've been looking at around here, sort of these, this sort of style but the round beads and stuff as well, so what sort of different styles are there from different areas and regions?

P: Yeah actually it's quite tricky yeah also because like it depends again on the artist how they want the style of the thing. Like look at this one here, see? This is more like letter 'Z' and look at how the artist cut this one here and more different than this one also so see, they're quite different

G: Yeah

P: So I think, from my personal view, is it depends on the artist again, how he wanted the artefact to look like. Like this one is good, maybe before he carve this, he knew exactly how it will look. So to me personally from my experience, like people come in with crafts every now and then. When I ask them questions they say it depends where you want to cut that and we first visualise and see how it will look and then we start to cut the shell, put the shell inlay there. So I think it depends on the artist, how they wanted it. But then, Western Province is quite different like this one is done by somebody from Malaita, but this thing is Central Province. So when he, when the Malaitans start to cut this, he look maybe look up in a book, in a history book or whatever, I don't know and then he start to do. He start off thinking of a different, this is different shell, this is not *Nautilus* shell, this is mother of pearl shell

K: Okay, from the pearl oyster

P: From the pearl oyster

K: Okay

P: That's different, not from the shell money necklace. Not from the oyster shell they use for the traditional currency in shell money. That's from mother of pearl. So we don't know why he use this, maybe because he don't have the *Nautilus* shell. Maybe not, but this is different. So this is done by Malaita man but the thing symbol is from the Central Islands

K: Okay. So this is almost unique to an artist that this is something that he's come up with?

P: I think so

K: Not a bigger tradition?

P: I think. So like this one here, this is Santa Catalina, Makira, San Cristobal but the eye is from the small cowrie shell, small shell. No that's quite different. As I've said yesterday, I think people from Makira lost their heart a bit from shell inlay because they start to come back to it. Like in some of the books that I've saw, they use shells also. Those shells and maybe, I'm not so sure if it is *Nautilus* shell but I think it is *Nautilus* shell then now, like this one is quite old, is about 20-30 years old, this thing here. But they don't use *Nautilus* and they use this cowrie shell. And this is also from the same place. So the artist, for me, if I look at something from Makira, or San Cristobal, I know exactly that oh you from, or even if like if somebody from Malaita maybe store it somewhere and then they bring it here then as straight as I look at it I know exactly that this is from San Cristobal. Then sometimes he deny it say 'no no this is from San Cristobal' but as long as I look at them I know exactly that that's from the part of the island. If Western Province, I know exactly that's from Western Province. I just see the difference. I can tell that this is from this part of the island

G: Yep

K: So when you see the inlay from San Cristobal and so on, is that almost inspired by the Western Province, you know, just looking at the way that they're cutting those inlay pieces and using them

P: Yeah there's some similarities where they carve it but it's not really neat as Western Province

K: No

P: No

K: So they've seen the idea and then they've sort of brought it back and

G: Replicated it, yeah

P: That's right

K: Okay

P: And try to make it, but still they won't catch up in the Western Province

K: No. No, okay. Right

P: Once somebody from south Malaita came with something, like a figure and I think that's one, right, the black one there. That black thing is done by somebody from south Malaita

K: Yep

P: It's quite, a bit different

K: Yeah, it's a very different style of figure too, isn't it?

G: Yeah definitely

K: So this is, is this Ari'ari

P: Ari'ari

K: Okay

P: And that not Malaita, that one there, this one here. That one with the bowl

G: To the right?

P: That's not Malaita. Right, I asked the lady who brought that in and said 'my husband used to be in the Western Province'. So that more looks more like Western Province inlay one but it's done by somebody from Malaita

K: Looking at this inlay on the side, they're just straight triangles, do you see this in the Western Province stuff? Or does that tend to be, no? Okay

P: Western Province stuff is more like this one here

G: Yeah, do you see that throughout Malaita or is it sort of just only people who are copying Western Province? So it's not really traditional?

P: Not really traditional. I think not really traditional from Malaita, I think. Because most people that I've talked with they say I lived in the Western Province so that's why I'm doing this so I think they tried to adapt

G: Yep

P: Yep. Maybe not, I'm not sure. Yeah

K: Okay so this is a little bowl I got last time and it's only about, it's tiny, it's only about this big but

P: This is Western Province yeah?

K: I thought it was Western Province but it has those sort of the triangles but then on the side

P: Yeah it's like this one

K: Yeah

P: I think they try to get some ideas from the Western Province they're carving so

K: That's just sort of a bit creative. Okay

P: Look at that, is Guadalcanal. They don't use shell. This big one here

K: The big one, okay yep

P: Just trade patterns

K: Yep

P: Also this is San Cristobal

G: Yeah it's just sort of more like a crude version of the Western Province stuff isn't it?

K: Yeah the inlay isn't sort of, they're not done in side by side, almost continuous

G: More spread out, yeah

K: Yep

P: I think they start to, try to copy. I think

K: How do the craftspeople of the Western Province feel about this?

P: No they don't care. All they want is they want money. That's what happen now

K: Yeah

P: It's quite difficult because other stuff from other places, people are doing it. So I think the government need to look into, because they tried, the government tried to put a bylaw. A province on bylaws. They do have bylaws, ordinances, that people from other provinces don't copy other items from other places. But now it's mixed, like Western Province, Malaitans have built things from [unknown]. They're doing art from different places, which I think we should look into

K: Yep

P: But, because the people who own these things are not doing it. So if they stop then it's finished

K: I think it's funny because the exception seems to be the Langa-Langa shell money, like it's only made there. We were talking a little bit with Peter yesterday that one of the differences with Langa-Langa is that it is still made for custom, for custom use. You have stuff that's made for tourism and for selling, but there's also that very specific side of production that is just for custom and so that, you know, it's almost like it doesn't have proper custom meaning if it's not from Langa-Langa so it keeps the tradition really centred in that place and if other people copy, then it doesn't have the same meaning or the same value. But he was saying that with the Western Province carving, that it's not something that you really do for custom, it's just something that's done for tourism and for selling. So it's sort of lost that connection with custom

P: That's true. I think it talks sense. But then, like the Langa-Langa custom, especially with traditional currency, traditional currency is widely used in the whole province but mainly Langa-Langa northern part, off Malaita

K: Yeah

P: Not like the Kwaio area, western. Is Kwaio they have different, like I bought some shell money from, those ones are old ones I want to give it to for the national collection. So I bought, yesterday I put them in there to just to have place to put so I just locked that thing. I locked it, I kept the one of the locks down from the gallery and I said 'I want to lock, because this ones is very precious'. We can't get that anymore yeah. I mean it's lost so

K: But the Kwaio they weren't making their own shell money?
P: No, that's shell money from Kwaio, that one. Two, two, yeah so that's different from Langa-Langa shell money

K: Yep

P: Tafuli'ae that's called [Banyaw] and then tafuli'ae is Langa-Langa shell money

K: Right, but the people on Langa-Langa they have the shell money they're making but they also make different types specifically for other, like they were showing me the Bougainville shell money which was completely different but then they take it directly up to Bougainville to sell there

P: Yes but you know, during the Festival of Pacific Arts in Guam, two places in [unknown] and Bougainville they come for the festival and that really attracts me to the stall because when I look at them dressing up, Bougainville, and it's just similar like Langa-Langa and the shell money is really old that they wear, very old, like very shiny like that and then I ask them all this is, we have similar shell money from Malaita but the difference is they have the white one and in Malaita they have the red one as the most valuable one

K: Yeah

P: I'm not so sure whether they have red shell money or not, but the ones they wear for the, it's really white but very like, very nice feeling

K: Yeah

P: So then I said 'Oh the culture is I think similar'

K: Yeah

P: But I think, I'll show you something from Santa Cruz Islands, that they use shell. I have one which I didn't sell. I got this basket and I didn't sell. That's the traders beads

G: What's the process for rounding?

K: You string them all on together [unknown]

P: See this is *Nautilus* shell

K: Oh yeah

P: And that's Santa Cruz. This is Santa Cruz Bō, we call it Bō

K: Those are really fine beads. Okay, wow. Do you know what the little beads are made from?

P: Shell

K: Yeah but do you know what type of shell?

P: They are from the same shell that Langa-Langa people used yeah

K: Oh okay yep so it's like a Spondylus? Wow, so this is an old one?

P: Yeah this is an old one. From Santa Cruz Islands

K: Sneaky trade bead

P: My costume actually, people used to ask for borrowing so I decided to buy something from Santa Cruz Islands if students need to do some, like they want traditional maybe costume, dressing here so they used to come and borrow it from me

K: Wow

P: So that is why I kept this ones back in. Students from college [unknown] borrow it once.

K: Okay. Take some photos

G: Yeah, absolutely

P: But different from Western Province yeah?

K: Yeah, very different isn't it. Yeah sometimes I've sort of seen something similar in that you know that the shell valuables from the Kula ring and the

Trobriands. They often have the *Nautilus* at the very end like this. Ah it's lovely. What's the yellow? Is that turmeric?

P: Turmeric

K: Okay, and that just transfers because it's on the skin?

P: Yep because they have to rub the turmeric on their skin and they wear this

K: So it transfers

P: And then it change the colour

K: Okay, excellent. So is it okay if Gavin takes some photos?

P: Yep, no problem. That's my personal one so it's okay

K: Great, excellent. So delicate, it's lovely

G: Am I able to take photos of the different pieces from the different areas?

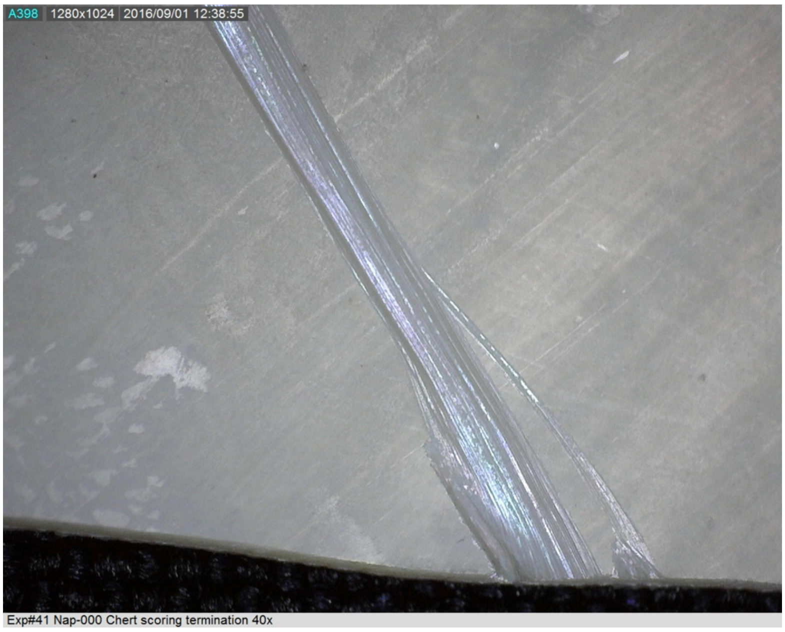
P: Yeah yeah, okay, alright. Maybe I'll just get something from different places and then

G: Yeah, that'd probably be good

<u>Appendix 3 – Worked *N. belauensis* septal wall fragment</u>

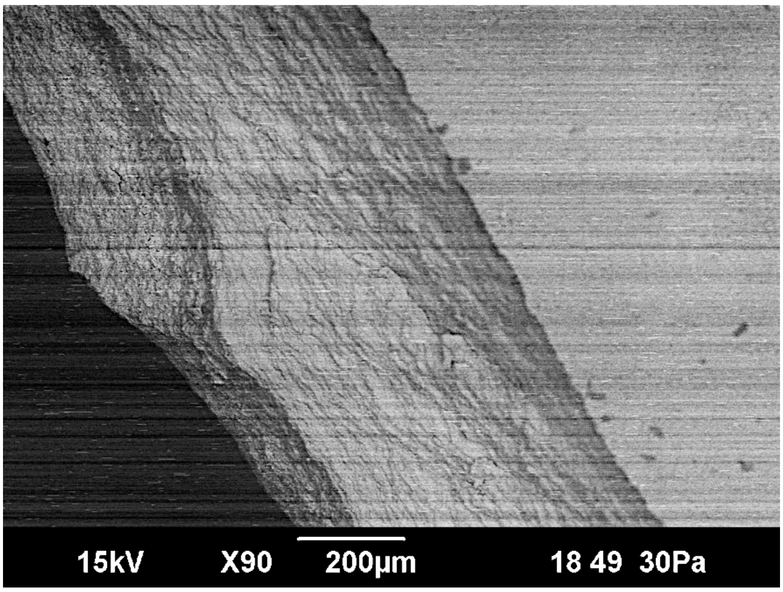
Appendix 3: Nab-003 exp#7 – *N. belauensis* Septal wall fragment scored with a chert for 50 gestures (50x).

Appendix 4 – Worked *N. pompilius* fragment



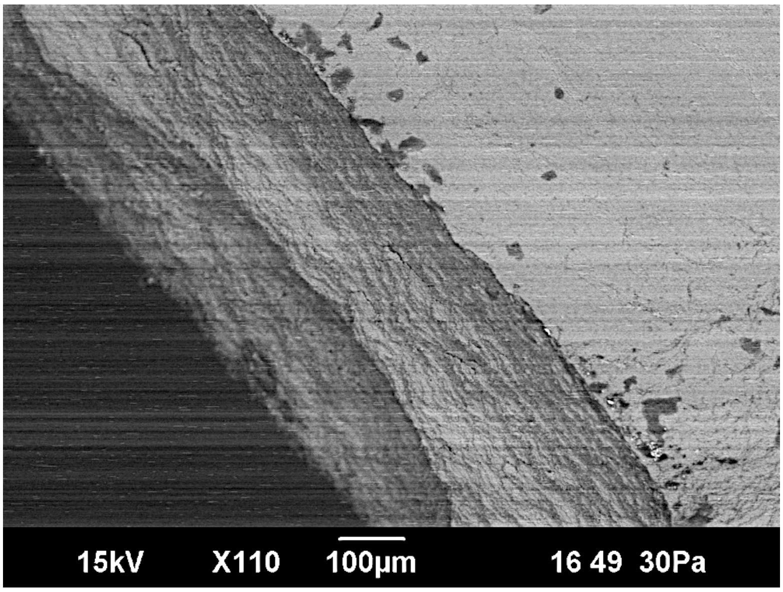
Appendix 4: Nap-000 exp#41 – *N. pompilius* fragment scored by chert for 100 gestures (40x).

Appendix 5 – SEM image of lamellar fracture of Nab-004a



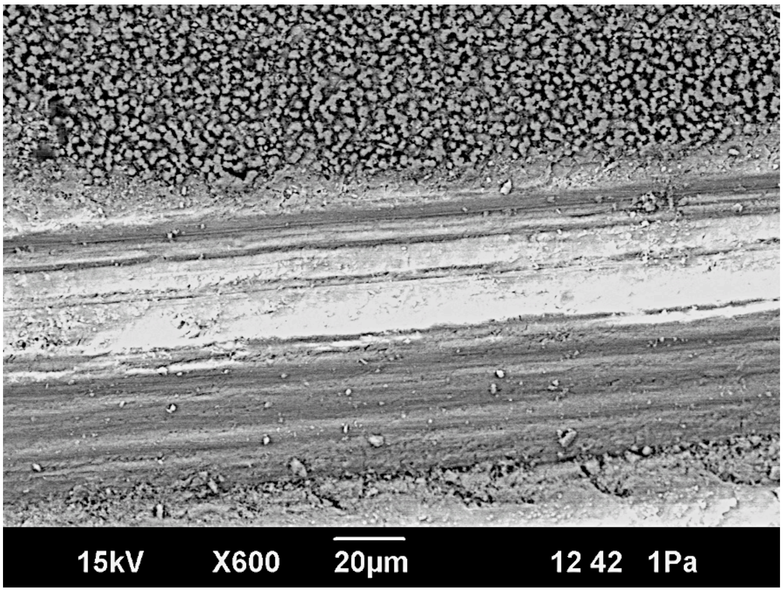
Appendix 5: Nab-004a – lamellar edge on INSTRON fractured *N. belauensis* fragment (dorsal/ventral compression) (15kV, 30Pa).

Appendix 6 – SEM image of curved fracture edge of Nab-004a



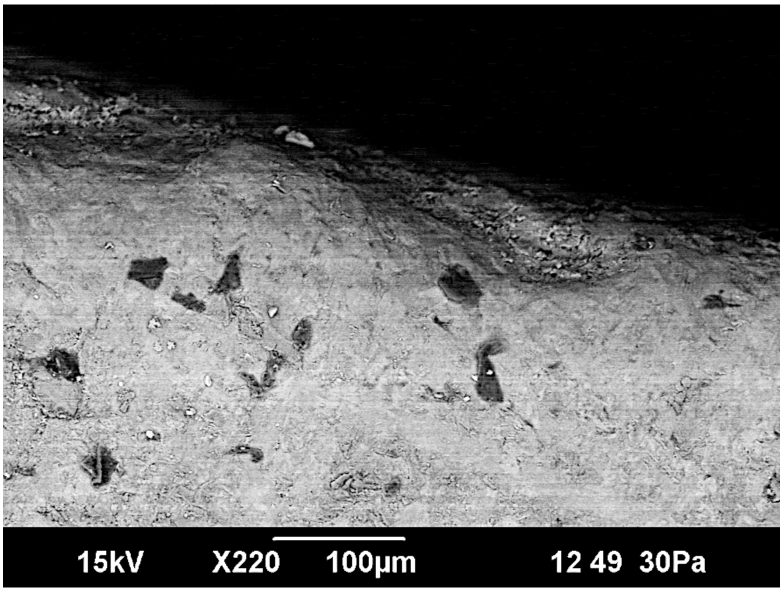
Appendix 6: Nab-004a – curved fracture edge on INSTRON fractured *N. belauensis* fragment (dorsal/ventral compression) (15kV, 30Pa).

Appendix 7 – Debris inside score on experimentally worked sample



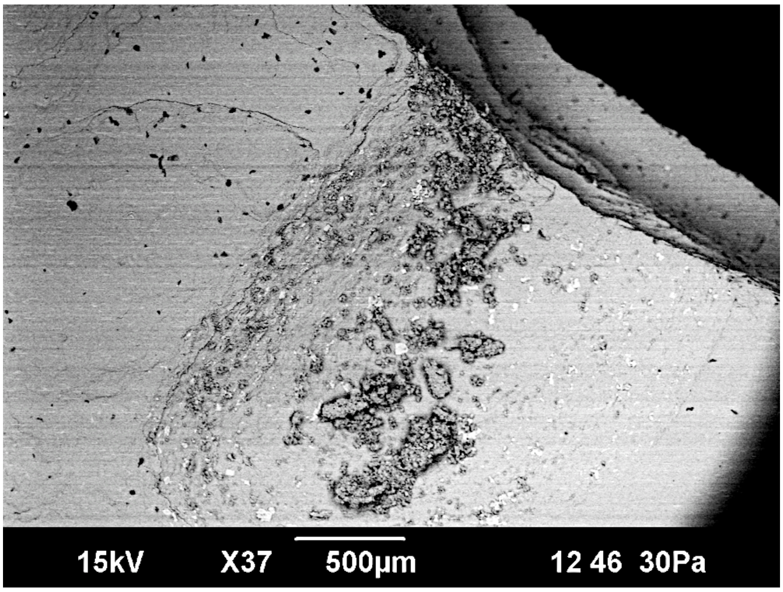
Appendix 7: Nab-001g exp#12b – debris generation inside score on *N. belauensis* score-snapped using chert for 100 gestures (15kV, 1Pa).

Appendix 8 – Edge rounding on ray skin worked *N. belauensis* fragment



Appendix 8: Nab-003 exp#51 – SEM image of edge rounding on *N. belauensis* fragment due to abrasion by ray skin (*Aptychotrema rostrata*) for 100 gestures (15kV, 30Pa).

Appendix 9 – Depression in the nacreous surface of fragment GC-007



Appendix 9: GC-007 – depression (containing residue) in the nacreous surface of the fragment (15kV, 30Pa).